THE EAST RIVER BRIDGE.

The space at our command forbids a detailed description of this great work just completed—to do justice to the subject would require a volume—but we present with the illustration contained in this number of ENGINEERING NEWS a collection of "data" which we hope will prove useful and interesting at this time. The sources from which the following is collected are mainly official reports of the Bridge Company, and they may be relied upon as correct, having been revised by the engineers in charge.

ORGANIZATION.—On Jan. 25, 1867, Hon. H. C. Murphy introduced into the Senate an "Act to incorporate the New York Bridge Co." This act became a law within the session of the Legislature named. By it the incorporators were empowered "to construct and maintain a permanent bridge over the East River;" the cities of New York and Brooklyn to subscribe such amounts of the capital stock as a two-thirds vote of the councils of the respective cities might determine, and issue bonds in payment of such subscription.

June 5, 1875, an act was passed vesting the entire control of the erection and completion of the bridge in the two cities, under the direction of eight trustees to be named by the Mayor and Controller of each city, the last named being *ex-officio* members of the board, thus making a total board of twenty members. By this act the capital stock of the original company was taken up, and all original subscriptions to that company paid back with interest from date of payment.

ENGINEERING.—On May 23, 1867, John A. Roebling was appointed engineer-in-chief, and at once began the preliminary surveys and plans. His original estimate of cost, exclusive of land damage, was $7,000,000; this amount was increased for reasons given further on. Mr. J. A. Roebling lost his life in July, 1869, by lockjaw, resulting from the accidental crushing of his right foot by the shock of a ferryboat against the fender-piles on which he was standing, directing at the time certain operations connected with the bridge.

In August, 1869, Washington A. Roebling was appointed chief engineer, to succeed his father, and continued to hold that position to the end.

At the request of John A. Roebling, a board of consulting engineers was convened to examine and approve the plans; these gentlemen were Horatio Allen, Benj. H. Latrobe, Wm. J. McAlpine, James P. Kirkwood, Julius W. Adams, J. Dutton Steele, and John J. Serrell.

In May, 1869, the War Department, in compliance with an act of Congress, appointed Generals Wright and Newton and Major King a commission of government engineers, to examine into the general feasibility of the project, and as to whether or not it would be an obstruction to navigation. These gentlemen recommended an increase of five feet in the elevation of the centre of main span, above mean high tide, making the height at that point 135 ft. It was determined at the same time to increase the width of the bridge from 80 ft. to 85 ft., giving a double roadway for carriages on each side of the bridge. The above changes at once vastly increased the cost, and practically necessitated a complete change in plans.

The executive engineering staff, from the commencement to the completion of the structure, was made up as follows: C. C. Martin, principal Assistant Engineer; Col. Wm. H. Paine, in charge of the preparation, inspection and testing of the various materials used in the bridge, and for a time in charge on New York side; Francis Collingwood, Engineer in charge at the New York end; and Geo. W. McNulty in charge of the Brooklyn side. Horatio Allen was Consulting Engineer during the building of the tower foundations.

THE BROOKLYN TOWER AND ITS FOUNDATION.

General Dimensions and Data.

Length over all of caisson	168 feet.
Breadth of base	102 "
Height of air-chamber	9½ "
Total height of caisson when launched	144½ "
" " " completed	271½ "
Cubic feet of timber in caisson	111,000 "
Weight of iron work	250 tons.
Launching weight of caisson	3,000 "
Bottom area of caisson	17,136 sq. feet.
Concrete in filling air-chamber	4,000 cu. yds.
Brick in piers under roof of air-chamber	250,000
Caisson launched at Greenpoint, L. I.	March 19, 1870.
" towed to Brooklyn tower site	May 2 & 3, 1870.
Air-chamber first explored	May 10, 1870.
Timber-work finished on caisson	June 20, 1870.
First stone laid of tower foundation	June 15, 1870.
Masonry reached high water-mark	Dec. 10, 1870.
Air-chamber filled with concrete	March 11, 1871.
Tower masonry completed	May, 1875.
Fire in caisson discovered	Dec. 2, 1871
Masonry in Brooklyn tower	38,214 c. yards.
Pressure per square foot on foundation due tower and superstructure	5 tons.
Top of masonry above mean high water	276½ feet.
Bottom of foundation below mean high water	44½ feet.

The first work done upon the bridge was the preparation for the Brooklyn foundation, commenced Jan. 3, 1870.

The material underlying the Brooklyn tower is a hard-pan with alternate layers of trap boulders imbedded in sand and clay. At a point 50 ft. below mean high water this material is so compact that the "bore-holes" stood for weeks without tubing. The rock, a gniess, lies 96 ft. below mean high water.

The foundation masonry to high water is Kingston limestone, in 24-in. to 28-in. courses; above foundations, the facework is Maine granite, backed by limestone. All backing is cut and laid in courses, with a minimum of mortar joints.

According to the time-book, 2,500 different men worked in this caisson. Of this number only six men were temporarily disabled by working in the compressed air; no lives lost. The men worked in eight-hour shifts. Each of the two "day gangs" was made up of 1 general foreman, 6 assistant foremen and 112 laborers; the special "night gang" was composed of 1 general foreman, 2 assistant foremen and 40 laborers; including the outside labor, the daily force was 360 men. Two dollars for eight hours' labor was at first paid; after passing a point 28 ft. below high water this rate was increased to $2.25, and so remained to the end.

The concrete used in filling the air-chamber, wells, water-shaft, etc., was made of one part Rosendale cement, two parts sand and four parts small gravel. It was laid at the rate of 100 cubic yards in 16 hours.

THE NEW YORK TOWER AND FOUNDATION.

General Dimensions and Data.

Length of caisson over all	172 feet
Breadth " "	102 "
Height of air chamber	9½ "
Thickness of timber roof	22 "
Total height of caisson	31½ "
Cubic ft. of timber in caisson	118,000 "
Weight of bolts "	180 tons
" iron work "	200 "
Launching weight "	3,250 "
Area of foundation base	17,554 sq. ft.
Concrete in air chamber (reduced by boulders)	3,300 cu. yds.
Weight of caisson	7,000 tons
Possession obtained of tower site	April, 1871
Work commenced in preparing for foundation	August, 1871
Caisson launched at Greenpoint, L. I.	May 8, 1871
" towed to tower site	Sept. 11, 1871
" last timber course laid	Nov. 1, 1871
" reached the rock	May, 1872
Concrete filling completed	July 20, 1872
First stone laid in foundation	November, 1871
Masonry of tower completed	July, 1876
Total masonry in New York tower	46,945 cu. yds.
Top of masonry above mean high tide	276½ feet
Bottom of foundation below mean high tide	78 "

The soil penetrated by the New York foundation was as follows: Black mud, 12 ft.; course sand, 6 ft.; gravel, 6 ft.; quicksand with boulders, 15 to 20 ft.; then gneiss rock lying about 75 to 78 ft. below mean high tide. The site was first dredged to a depth of 37 ft. below high water before the caisson was launched.

The New York caisson differed from that used in Brooklyn in having the air-chamber lined with a skin of No. 6 gauge of boiler plate, to strengthen it and make it more safe from fire.

The character of masonry was the same as that described for the Brooklyn tower; the New York tower is 3 ft. thicker than the Brooklyn tower.

THE ANCHORAGES.

Size at base, of each	129×119 ft.
" " top, " "	117×104 "
Height, at front, 89 ft. above M. H. W., at rear	85 "
Weight of each anchorage	60,000 tons.
Total number of anchor plates	8
Total weight of each anchor plate	23 tons.
Dimensions of " " "	2½ ft. thick, 16×17½ ft.

(For size and number of bars for each cable, see plate).

THE MAIN CABLES.

Total number of cables	
Wires are galvanized steel, oil coated, laid parallel (not twisted), weight per foot of single wire, nearly	1-11 lbs.
Total number of wires in one cable	5,296
" " of strands " as laid	19
Diameter of each cable, when wrapped	15¾ inches
Length of each single wire in cables	3,579 feet
" wire in four cables, exclusive of wrapping	14,371 miles
Solid section of each cable	144 834-1000 sq. in.
Weight of each cable	1,732,086 lbs.
" four cables	6,928,344 lbs.
Ultimate strength of cable per sq. in. of solid section	170,000 lbs.
Ultimate strength of one cable	24,621,780 lbs.
" four cables	98,487,120 lbs.
Wrapping of main cables, annealed wire	No 10
Miles of wrapping wire on each cable	243 18-100
No. of suspenders from each cable, main span	208
" " " " " land span	80
" post-bands, each land span, each cable	35
Strength of a single suspender	140,000 lbs.
Max. load on a single suspender	20,000 lbs.
No. of over floor stays	400
Weight of suspended superstructure from anchorage to anchorage, 3,460 ft.	6,620 tons
Weight of suspenders, cable bands, floor stays, railing, propelling rope and sheaves, etc.	1,180 "
Weight of cables	3,460 "
Weight of timber flooring	2,760 "
Weight of steel rails, guard rails, and iron floor	660 "
Total permanent weight of bridge	14,680 tons
Total transitory load on bridge	3,100 tons
First temporary wire rope for cable making stretched	Aug. 14, 1876
E. F. Farrington, in charge of cable making, first man to pass from tower to tower, on rope	Aug. 25, 1876
First cable wire run out	May 29, 1877
Cable making really commenced	June 11, 1877
Cable making finished	Oct. 5, 1878
Greatest length of wire run in one day	88 3-5 miles

TRUSSES, &C.

Total number of Trusses	6
Center Trusses, height between pin centers	17 ft.
" " width, clear of posts	12 ft. 8 in.
Side Trusses, height between pin centers	8 ft. 9 in.
Cross Floor beam, total length	80 ft.
" " depth out to out	32 in.

GENERAL DATA.

Length of river span, centre of towers	1,595½ ft.
" each land span	930 ft.
" Brooklyn approach	971 ft.
" New York "	1,562½ ft.
" total, of bridge and approaches	5,989 ft.
Width of bridge	85 ft.
Height of floor at towers above M. H. W	119 ft. 3 in.
" towers above roadway	159 ft.
Grade of roadway, per 100 ft	3¼ ft.
Clear height of bridge above M. H. W. in center of river span, at 90° F.	135 ft.
Total cost of Bridge	$11,700,000
" land damages	$3,800,000

THE BRIDGE AN OLD IDEA.

The following article is taken from the Lowell (Mass.) *Mercury*, November 14, 1829, and is reproduced *verbatim et literatim*:

A project has been set on foot in N. York to unite that city with Long Island by the erection of a bridge across the East River to Brooklyn. The N. York Gazette of Friday furnishes the outlines of the proposed plan, which we have copied below:—*Bos Bulletin.*

"It is contemplated to have a chain suspension bridge, thrown from the heights at Brooklyn to the foot of Maiden lane, being the most eligible spots, and in the city nearest to the seat of business. The main piers will project from the New York and Brooklyn sides 300 feet into the river, forming three arches, until they reach the wharf or landing, which will leave the centre or main channel, 500 yards for the passage of vessels of the largest class. The length of the bridge between the tollgates on each side will be 2,100 feet; the heights of the piers from high water line to the level of the floorway will be 160 feet, and from the floorway to the extreme point of the suspending pier, 65 feet. It is contemplated to have two carriage ways, each 12 feet wide, with a centre passage of four feet for passengers. The heaviest part of the work will be the stone abutments and suspension piers. These will form a solid work of granite, of gradual de-

scent, with a fall of one foot in every ten; and if the abutment is fixed at the foot of Maiden lane, the ascent will probably commence from Pearl street, leaving light and airy arches over Water, Front and South streets for traveling. The chains for the level of the carriage ways will consist of sixteen, connected with chain plates, bars, bolts, and vertical and trussed rods; the flooring will consist of three tiers of planks, three inches thick, two laid transversely and one longitudinally, with side guards of oak. It is computed that upward of 2,800 tons weight of iron will be required to complete the suspension part of the bridge, and the aggregate estimate of the cost of the work will be something more than $600,000. The necessary drawings and models will be exhibited upon the formation of the company. It is supposed $100,000 are annually paid in ferriage across the East River, and on a reduction of one-third of the present rates, the nett receipts of the bridge with the increase of traveling, will be $150,000—and New York and Brooklyn will resemble London and Westminster. The rise of property in Brooklyn alone will defray the expense of the project. A suggestion of great importance has been made to the projector, by an intelligent gentleman, which is to lay down pipes of large calibre, under the flooring in the centre and on each side of the bridge, for the conveyance of pure water from Brooklyn, which, from the difference in height, can readily furnish an ample supply for the city at very little additional expense. It is altogether a project of great interest to the city, and apparently feasible, as chain suspension bridges are superseding the old plan throughout Europe."

ENGINEERING EDUCATION.*

BY PROF. C. H. M'LEOD, M.A.E.

Our early engineers, both in America and the mother country, were largely self-taught men; men who rose from the ranks—carpenters, masons, bricklayers, blacksmiths—men having little of what is now called education, but men of courage and patience; men possessing judgments well trained in the observation of nature's laws; these were the men who, by years of persistent toil, founded the profession of engineering. We must always bear in mind that they were men who had to feel their way cautiously through unknown paths, and who only mastered some of the facts and principles which are now familiar to every student of engineering after much labor and loss of time. There was no such thing as a school of engineering in those days; it was the dawn time of the science of engineering. As public works became more numerous and the demand for engineers became greater, young men of a practical turn of mind were drawn to the craft—it had not then the rank of a profession—and found occupation as assistants to the older engineers. In this way the system of apprenticeship arose, under which a young man, upon payment of a premium or otherwise, entered an engineer's office to learn what he could. No attempt was made to teach him, He—the engineer of the future—had even yet to rise by self-teaching; but he was given an opportunity to see work being done, to acquire knowledge by observation.

Engineering literature presently began to appear, and the apprentice had access to such works as "Pambour on Locomotives," "Vicat on Cements," "Wood on Railroads," books which were valuable because they had chiefly reference to actual works, being mainly descriptive. This was a time of fact, not of theory, a time when it had not yet begun to be fully understood that theory and practice are one.

While in England the system of apprenticeship continued to be the national school of engineering, the French people set about the education of their engineers in a different way. They established a polytechnic school. In this school, says Professor Vose, "it was recognized that civil engineering was largely a mathematical business, and it seemed to be assumed at the start that if a little mathematics was good, more mathematics was better, and the most mathematics was the best; many leading minds in that eminently mathematical nation set to work to reduce engineering to a mathematical science, and volume after volume, upon the location of roads, the stability of retaining walls, the transportation of earth, the application of descriptive geometry to the construction of masonry, and other like matters appeared, in which all the resources of the higher mathematics were exhausted, and which showed the authors to possess every accomplishment except, perhaps, a little common sense." But this statement, though no doubt true, is not the whole truth; the discussion of applied mechanics soon fell into the hands of men having practical as well as scientific skill, and finally the harmony of theory and practice in mechanics was reached and the science of engineering established by such men as Rankine, Weisbach, Willis, Reuleaux.

Professor Vose also informs us that the early American engineering schools were based on the model of the French school, which he describes, and intimates that the ideal school was the one which could stuff into its students a maximum of mechanics, practical or unpractical. Here we find the other extreme in engineering education. Too much theory, too little observation and practice.

It is to-day recognized on all hands that mathematical skill must be tempered with a good deal of judgment and practical knowledge before it can be of any great use. But it is equally true that ever so sound a judgment, ever so much common sense, is quite at sea in an attempt to overcome even the simplest engineering problems without a scientific training in applied mathematics. Such a statement as this instantly calls to mind works of stability, works which have perhaps won renown for designers who were not scientifically trained men. There may be exceptions, but in general the designs of such men make up in massiveness—which implies unnecessary expenditure of labor and material—what they are unable to provide for by skillful arrangement of the parts of the structure. There is a perversion of public taste in regard to massive structures, which, as Professor Rankine has observed, "causes works to be admired, not in proportion to their fitness for their purposes, or the skill evinced in attaining that fitness, but in proportion to their size and cost." At least one of our ablest Canadian engineers and designers does not scruple to confess that he is hampered at every turn by lack of mathematical knowledge. We know that you, in the practice of your profession, will not have cause for such regret, for we have reason to be proud of the training given in McGill, on the subject of applied mathematics. We also know that you have the ability to apply it—to this, any one who has inspected your designs will bear testimony, and I may add, with regard to one of these designs in particular, that it has called forth the warmest admiration of one of our most distinguished engineers, to whom it was exhibited. I mention these facts because I wish those who are here to-day to know that we have done and are doing good work, and also because I am going to point out presently certain defects in our instruction, defects which, with our present appliances are unavoidable.

We have seen that the competent engineer must possess a sound judgment, and we know that to grapple successfully with any problem in engineering science, he must above all things have an intimate knowledge of the nature of the materials he is to employ and his knowledge must not be the knowledge that comes from hearsay or from books alone; it must be the knowledge that comes of seeing, handling, analyzing and testing. He must know the action of his materials under the various conditions in which they are to be employed. Further than this, he should know how to set about testing his materials, be they iron, steel, sulphur-bronze, delta, stone, timber, cement or brick. He should be able to learn all about them, and to know what to expect of them. To discover the precise value of a material for constructive purposes, its limit of elasticity is of much greater moment than its limit of rupture. To determine the limit of elasticity of a material involves the power to make very minute measurements. To determine the value of many materials, a chemical analysis is necessary. To understand thoroughly the properties of steam—the values of the different methods of jacketing; the most economical steam pressure, speed or point of cut off for given conditions; the relative merits of wet, dry and superheated steam; and the innumerable other details connected with the management of steam—the engineer must have an opportunity to study them beside an engine which can be converted at will into any required condition—an experimental engine, in fact—or else he must slowly learn from different forms of engines as he may chance to meet them in his practice. Now, to make these investigations constitutes the work of the mechanical laboratory, and this is just the kind of experience which is best fitted to educate the judgment, to ripen the discerning powers. We have the testimony of no less an authority than Mr. Faraday that judgment is largely a matter of education.

It is the realization of these facts which has caused what we may perhaps call a reform in engineering education during the last few years. In all the leading schools of England and the United States we find that extensive mechanical and physical laboratories have been established; not show establishments, but places where every student has to do the work set before him with his own hands—where he learns to make fingers out thumbs—and where, to the greatest possible extent, he draws his own conclusions. One of the great results of such an institution as this is to impart to its students a love for original investigation and a knowledge of the methods of conducting such work, which will, in after years, prove of inestimable value, not only to the student, but also to the country to which he belongs. That such an institution has not been established in McGill is not our fault, nor the fault of the governors of the university. We have not the means.

*Extract from an address to the Graduating Class of 1883, Faculty of Applied Science, McGill University.

A NEW TRANSIT.

An improvement in Engineers' Transits has recently been made by Mr. Blattner, of the firm of Blattner & Adam, manufacturers of engineers' instruments, St. Louis, which we consider of great importance to Civil Engineers and Mineral surveyors.

FIG. 1.

Fig. 1 represents a transit with this improvement, and at the first glance presents no peculiarities, but in Fig. 2 we can see the novel position in which the instrument can be placed.

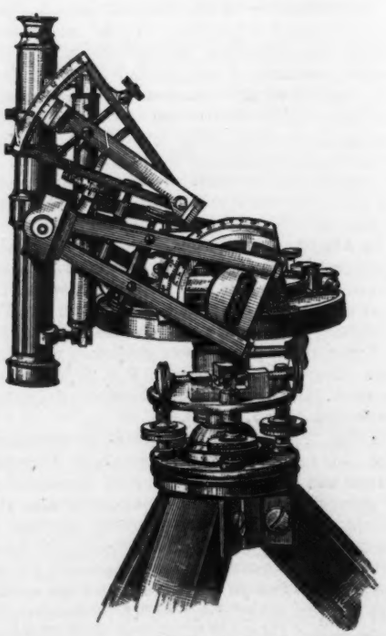

FIG. 2.

The manner in which this is done is to fasten each standard to the upper plate by means of a stout journal and its bearing, the position of the standards is controlled by a clamp and two opposing

screws, by means of which the standards can be set at any angle from a vertical to a horizontal position.

The advantage of this is that the standards can be set in a position to sight down or up steep places, from bridge piers, a declivity, or even a shaft, in a perfectly vertical line.

An entirely new style of vertical arc is here presented, as will be seen in either illustration. This arc serves as a latitude arc when using solar attachment; the standard carries the vernier. The movement of telescope in altitude is independent of the solar attachment, a great advantage.

The illustrations also show level on telescope and gradienter screw to axis.

Mr. Blattner has adapted this improvement to Compass Transits for land surveying, of which we gave an account last week.

Letters Patent have been granted for this improvement and others are now pending.

THE MONONGAHELA SUSPENSION BRIDGE, AT PITTSBURGH, PA.

BY COL. S. M. WICKERSHAM.*

In order to a proper conception of construction of thirty-eight years ago, in which time more than a generation of men have come and gone, it might be well to look into the then existing state of affairs bearing on the subject, and to try and understand the difficulties which the engineer had to encounter considered in respect to the resources at his command with which to meet them. At that time work in the shop was done principally by hand. The slide rest was a novelty, and the straight-edge and steady eye and hand turned out the piston rod. Screws were still cut in the lathe by hand. The whip-saw was used to cut the floor beams of the aqueduct in 1844. The trip-hammer was still doing its noisy work, afterwards so effectually silenced by the squeezer. The canal-boat controlled the freight traffic between West and East, and steel was almost among the precious metals. But it would occupy too much time to go into this interesting part of the subject. We will therefore ask your kind attention to a simple narrative of events preceding and leading to the construction of the Monongahela Bridge, and to an account of the method pursued in its building. I regret much being disappointed in obtaining some drawings which would have added interest to the description, so must do without them.

Up to the beginning of 1845, the bridges throughout this country were built of wood, wood and iron combined, or of stone, a few of chain—all generally of short spans, wood being the principal material used. The bridges were generally for highways, for foot and wagon traffic. Although about 15 years had passed since the introduction of railroads, they had as yet not been extended very far. It was in 1845 a company was formed to build a railroad from Harrisburg to Pittsburgh. It was in 1845 a company was formed to build a telegraph line from Philadelphia to Pittsburgh. Here commenced the era of railroads which from its necessities produced the present era of iron and steel bridges.

At Philadelphia, Pa., a wire suspension bridge had been erected, spanning the Schuylkill River at Fairmount, at the expense of the county, by Chas. Ellet, Jr., C. E., who furnished the plan and contracted for the work at $50,000. The abutments and columns were of granite, the distance between abutments 343 ft, between the supporting rollers on top of the columns 357 ft, width of floor and foot-way 27 ft. The wire was laid in 10 cables, 5 on each side of the bridge—each cable extending from anchorage to anchorage over the top of the columns, and were fastened at the ends around numerous stout iron bars transversely imbedded in the solid rock or in an immense body of masonry—this formed the anchorage.

Each cable was composed of 260 No. 10 wires, forming a strand 2¼ in. in diameter, weighing each 4 tons, and each being 650 ft. in length. They were wrapped at short intervals with bands of wire. The cables lay in a horizontal plane—across the 5 cables iron bars were laid, to which were attached the suspending rods, which were composed of small wires aggregating an inch in area, which, hanging vertically, as did also the cables, were attached to the beams that supported the floor. This bridge was opened for travel in the spring of 1842. It was erected on the site of the wooden bridge built in 1818 by Lewis Wernwag, which was well known as being the longest single span wooden bridge in the world—343 feet between the abutments. It had succumbed to fire, the almost universal fate of wooden bridges.

* Paper read before the Engineers' Society of Western Pennsylvania, May 15, 1883.

There was no element of stiffness in the Fairmount suspension bridge, and it was subject to great vibrations. It was very graceful and pretty to the eye, but very unsteady to the feet.

This method of construction had been severely criticised by Mr. John A. Roebling, and a controversy had arisen between these distinguished engineers, Mr. Roebling maintaining that suspension bridges could be built possessing elements of stiffness and rigidity by a proper combination of its own elements, that by laying the wires in cables of larger diameters the stiffness of a solid bar could be obtained. Mr. Ellet held it to be impracticable to combine the wires into a cable of large diameter so that each wire would bear its proper share of the burden, and that therefore the wires must be laid in cables of small diameter, adding to their number as additional strength was required. So the contest rested until 1844, when Mr. Roebling contracted with the city of Pittsburgh to rebuild the aqueduct across the Alleghany River, connecting the Pennsylvania canal with the basins within the city, which enabled him to introduce the plan of suspension bridges he had so contended for. There were 7 spans in this work; there were 2 continuous cables made of No. 10 wire B. G., each 1175 ft. in length from anchorage to anchorage, 7 in. in diameter, formed of 1900 wires each, gathered into a round cable, and tightly and closely wrapped throughout with No. 14 annealed wire. The cable passed over stone pyramids on each pier and on the abutments, resting there on rollers. The suspension rods passing over the cables descended between the floor beams, which were put up in pairs, and block and washer below. The trunk was so made of two courses of 2½ in. plank, crossing each other diagonally and held together by the side post and framing, as to be self-sustaining, so that the cables had really only to carry the weight of the water within it.

The total weight of water in each of the seven spans when the canal was full 295 tons; weight of one span, including all, 420 tons; average ultimate strength of each wire, 1100 pounds; tension of one wire, 206 pounds.

Thus for the first time did Mr. Roebling introduce his system. But it was objected that the load in the aqueduct might be considered as constant, and the excess of strength was so great that many inequalities might exist and not become manifest for a long time, owing to the entire absence of vibrations, and therefore it was not a solution of the point at issue.

The work on the aqueduct was drawing to a close. It was opened for navigation on May 22. When, on April 10, 1845, the bridge over the Monongahela River at the foot of Smithfield street, Pittsburgh, which had been erected in 1818 by J. H. Johnson, after designs of Lewis Wernwag, was destroyed in the fire which on that day swept over the city, leaving 40 acres of ruins where in the morning had stood the principal portion of Pittsburgh's business houses. The blow was stunning and for a time it seemed that it would be fatal to our prosperity. But soon the native energy asserted itself and the work of restoration commenced.

The bridge company felt the necessity of re-establishing communication with the South Side, but were in no condition to incur any heavy expense. Every one seemed to be ruined, and it was questionable whether the needed funds could be raised. The cost of erecting the bridge was an important consideration.

Mr. Roebling seized the occasion to make and offer a plan and estimate for a wire suspension bridge, in which the abutments and seven dilapidated piers of the burnt bridge could be utilized, and having all the mechanical appliances required in the execution of the work, together with the skilled and unskilled workmen still with him at the aqueduct, determined not to miss the opportunity of introducing his distinctive method of construction to the world; he therefore made his estimates at a figure just sufficient to cover actual cost, leaving to future works his proper remuneration, and in this the near future richly proved his wisdom. The offer of construction was so low that the bridge company accepted it, and twenty days after the destruction of the old bridge, namely, on May 1, work of preparing for the new was commenced.

The abutments and piers of the old bridge had been greatly damaged by fire; the injured portions were taken down, and they were thoroughly grouted before the new masonry was laid.

The piers were 50 ft. in length at bottom, 36 ft. high, 11 ft. wide at top, battering 1 in. to the foot. Two bodies of substantial cut stone masonry, measuring 9 ft. square and 3 ft. high, were erected on each pier at a distance of 18 ft. apart. On these the bed plates were laid down for the support of the cast iron towers, to which the cables were suspended by means of pendulums, each span being supported by two separate cables—there being in the whole bridge 16 cables. Anchor rods for the towers were properly placed and walled in the masonry, anchor pits were dug within the abutments to a proper depth, a plank box made and placed on the bottom filled with cement grout, then the anchor plates with the first links were let down in the cement, a floor of double planking laid on top of the plates, and the masonry commenced and carried up, the spaces around the links being grouted with cement as the work progressed. On the curve the knuckles rested on cut stone; thus all the links composing the anchor chains were built solidly in the mass of stone until they reached the surface. Emerging from the masonry they extended a distance of 45 ft. to the top of the towers on the abutments, where they were attached to the pendulums and formed the connection with the cables. They were carried up from the anchor plates on such a line as to throw the strain which they were to resist inside the foot of the abutments, insuring the stability of the structure so far as the ends were concerned.

The towers were composed of four columns connected by four lattice panels secured by screw bolts. The panels up and down stream closed the whole side of the tower, but those in the direction of the bridge formed an open doorway, which served for the continuation of sidewalks from one span to another.

On top of the columns a massive casting rested which supported the pendulums to which the cables were attached; the upper pin of the pendulums laid in a seat which was formed by the sides and ribs of a square box occupying the center of the casting. For the purpose of throwing the whole pressure upon the four columns underneath, 12 segments of arches butted against the center box and rested with the other end upon the four corners.

The pendulums were composed of four solid bars of 2 ft. 6 in. from center to center of pin, 4x1 in., with heads of 8 in. diameter, pin holes 3 in. diameter. To the lower pin the cable of one span was attached directly, and the connection formed with the next cable by means of four links of 3 ft. 6 in. long and 4x1¼ in. section. I may here quote the language of Washington A. Roebling, the distinguished son of John A. Roebling, "that the peculiar features of this bridge were the pendulums, as by means of these any concentrated load upon one span was distributed over all the others, from anchorage to anchorage. By means of these it became possible to use the small towers which were built upon the narrow piers of the old bridge.

Whilst adopting the pendulums for this bridge Mr. John A. Roebling did not recommend their general use. In consequence of this pendulum system several times during the existence of the bridge our rivermen were enabled to pass under with their boats, whereas without it they would have had to await the fall of the river—in cases where they lacked up to 9 inches of headway in the channel span—they would have all wagons stopped in the two contiguous spans, thereby depressing them and raising the channel span so as to let them through, and this was often of great importance to them.* Before the completion of the piers and abutments an earnest effort was made by Mr. Roebling to be allowed to raise the level of the bridge ten feet—the expense of which was estimated at $10,000—but without avail; quite a bitter controversy arose on the subject. The up-river interests called for its raising. Here it was urged that giving a greater headway over the channel might enable boats to ascend direct to Brownsville, making Pittsburgh but a way station between the West and the East. In those days Brownsville was the point where the National Road—one of the main arteries of Western travel—struck the Western waters—from thence handsome packets brought the traveler to Pittsburgh, and this travel formed an important item in our resources, as the passengers generally laid over at least one night in Pittsburgh before taking steamers for their Western homes. This delay furnished opportunity for our merchants and manufacturers to secure many good customers, and the general feeling was averse to doing anything that might impair this advantage and move the head of navigation to Brownsville. In June, 1845, the Brownsville *Herald* charged the Hon. Wm. Wilkins, then president of the Bridge Co., as successfully opposing the rebuilding of the bridge at an increased height on the ground that it would let boats pass up to Brownsville to the injury of Pittsburgh. Mr. Neville B. Craig, then the able editor of the Pittsburgh *Gazette*, in reply said he doubted the correctness of the report and denied that the rebuilding of the bridge at the old grade or a higher one would have any effect on the business of Pittsburgh, adding—"This is sheer folly. Pittsburgh, from her size and wealth, her geographical position, her situation at the terminus of the Pennsylvania Canal, and as the converging point of roads and trade and means of intercourse with a wide extent of country, is eminently a point for commencing and closing voyages. In this respect no other place on the Western waters equal her, except St. Louis and New Orleans. How preposterous, then, to suppose that the raising or lowering of a bridge is going to effect her trade. We would be glad to see the bridge raised to give our Brownsville neighbors the fullest

* Since writing above I am informed that on one occasion Mr. Robinson, by means of heavily loaded coal teams, raised the channel span 14 inches and passed his boat under.

opportunity of rivaling Pittsburgh." Again, on the 26th of June, Mr. Craig expressed the wish that the bridge might be raised to the level of Smithfield street. But the reason given for not raising the height of the bridge, and which we may receive as the correct one, was the low condition of the finances, the gloomy existing state of affairs generally, and the fear of getting into trouble by saddling themselves with an additional debt of $10,000 at that time, and, all circumstances considered, a fearful amount. The construction of the bridge was therefore continued on the original plan without alteration.

While the work was progressing on the abutments and piers, the wire for the cables was being made. There were at that time but two wire factories existing west of the mountains, "Townsend & Co., at New Brighton, Pa.," which establishment is still in existence and noted for the excellent quality of its product, and the "Pittsburgh Wire Works, Saml. M. Wickersham," which works were swept out of existence by fire in 1850 and never rebuilt. To these two works was given the contract to make the wire for the cables, and about equal quantities were made by each. The greater portion of the iron used in the manufacture of the wire was made and rolled into ¼-inch rods by "Lyon Shorb & Co., of Sligo Iron Works," and it is well to mention here as showing the advance in 38 years in the manufacture of iron that the rods then furnished generally weighed but 8¼ lbs., though some were rolled of 11 lbs., weight, and when they came from the rolls were so chilled as often to be blue, and always requiring to be annealed before giving them the first break down, and then a second annealing and scouring before finishing to No. 10 for the cable. The wire was finished hard and bright. Now it is possible to have rods of steel of 100 lbs. weight, and finished so soft as to admit of being drawn into wire of same number with the proper hardness and ducility and strength with but one annealing.

The wire for wrapping the cable was drawn to No. 14 and finished by annealing. The anchor and pendulum bars were made by W. H. Everson himself in a small forge, consisting of a not very heavy helve hammer and heating furnace, where he could be daily seen with his leathern apron on handling the tongs, a prototype of Pat Lyon, at the very spot on which now stands one of the great iron works of Pittsburgh, and at the head of which Mr. Everson still remains.

The Pennsylvania Iron Works is the 38 years' growth of the modest Pennsylvania Forge.

Mr. Everson made the plates out of Juniata blooms—they were required to be of 65,000 lbs. tensile strength per square inch—the fact was they were made of what was considered the best iron to be had, and Mr. Everson's knowledge of the quality was the real test the iron was subjected to. All the material used in the structure was closely examined and tested by Mr. Roebling by all the means then at hand—for well he knew that in so light a structure quality became of the greatest importance, and, so far as he could do so, he allowed nothing else to enter into it.

Each wire was tested to 1,200 lbs. tensile strength, it was also held in a vise or in the plyers and bent to a right angle, then bent over to the same angle in the opposite direction, then straightened up; if it stood this without fracture it was received; if not, it was rejected.

At this time the ground on the south side above the bridge site was in open fields; there the workshops were erected and the cables made. Two platforms were built of a height equal to the required deflection, at a distance apart equal to the length of the cables; an iron pin fixed on each platform on which a cast-iron shoe was placed; a guide wire was stretched from pin to pin, giving the exact length and deflection of the cable. The cables were formed from a continuous wire, the short wires composing it being connected by tapering the ends for about 3 inches with a file, placing the scarfed sides together and wrapping the joint with a fine annealed wire; the wire was then taken from the reel and the bight carried by a wheel from one pin to the other. By means of a hand-windlass and a pair of pliers to clutch it, each wire was drawn up to correspond with the guide wire in the center. When thus 750 wires were in their places they were clamped and wrapped by the wrapping machine, worked by hand from end to end the No. 14 annealed wire into a compact round cable. When finished, by aid of a large screw, the cable was drawn back, slipped from the pins and laid upon the ground; the wires were each coated with boiled linseed oil and the cables well covered with white lead paint to prevent oxidation. When all the cables were completed planks were laid upon the ground, and by means of rollers and fall blocks they were moved to the river side and placed on flat boats which had been coupled together end to end, the boats were then dropped to and anchored between the piers.

The towers being well guyed to avoid pulling them over while the cables were being hoisted to their places, blocks were attached to their tops and the cables raised and connected to the pendulums This part of the work was commenced in the 2d or 3d span from the Pittsburgh side, hanging both cables and working both ways until all were in position. Then commenced the laying of the floor beams; these were of white pine, 31 ft. long 4½ ×15 in.; they were placed in pairs at a distance apart of 4 ft.

The suspension rods, made of 1½ in. round charcoal iron were attached to clamps which embraced the cables, and then passed between the floor timbers and through a bearing block and cast iron washer below. In hanging the beams care was taken that the spans should not be loaded too heavily at one place, so when 7 or 8 were hung on one side the span the same number would be put on the other side and thus alternately placing them would finish each span in the center.

The floor was double, the first laid lengthwise of the bridge, the second across; the roadway was 20 ft. in width, separated from the sidewalks by fender rails. The sidewalks were each 5 ft. in width, elevated a few inches above the roadway, and were outside the cables. The total width between the railings was 32 ft. The railing was an open lattice of sufficient depth to be self-sustaining, and was one element in giving stiffness to the bridge. A curious circumstance, and worthy of record, occurred at several times to this railing; it was finished with a broad cap-piece running lengthwise of the bridge, covering and concealing the ends of the plank forming the lattice-work. Owing to the vibrations of the bridge this cap-piece would work somewhat loose and take a sliding motion, and several times the friction thus caused set the rail on fire. The movement was of slight extent, but so rapid as to produce this effect.

The opposite cables, as well as the pendulums, were inclined toward each other, the distance apart being 27 ft. at the top of the towers and 22 ft. at the center of the spans. The pendulums on the abutment occupied a vertical position.

The floor was further supported by a number of stays, made of 1½-in. round charcoal iron, extending from the tops of the towers to the beams below for a considerable distance on each side of the piers. Timber supports also extended a short distance from each pier and each abutment; a wooden beam extended across the bridge from top to top of the towers, for the purpose of resisting the side tension of the cables.

As stated, the tearing down the portions of the old abutments and piers, which had been injured by the fire, was commenced on May 1st, 1845. The new work was begun in June, continued without intermission through the summer and fall and following winter—a great portion of the work having to be done in the cold weather of the winter.

The bridge was thrown open to travel in February, 1846, eight months after its building began and nine months after the contract for its erection was signed; but it had been used once before. On the night of 31st December, 1845, the ice in the Monongahela River broke up owing to a sudden rise. At noon of January 1st, 1846, to relieve the great inconvenience, the first floor having been just laid, the passage of wagons was allowed for one hour, and with great trepidation did the worthy treasurer of the company, Mr. John Thaw, walk to and fro until the whole stream of wagons and other vehicles, occupying at times the entire length of the bridge, as many as 7 teams being on one span at one time, had passed safely over.

The whole cost of the bridge was $55,000.

The masonry cost	$13,120
The superstructure cost	41,880
In all	$55,000

It is probable that no other bridge in the world, of same length, having a double carriage way and two sidewalks, has ever been constructed so cheaply.

The bridge is memorable as the first example of the solid wire cable being in great measure depended on to give not only support to the bridge, but also resistance to oscillations. The combination of the wires composing it, into one tightly-bound cylinder, while giving a strength of unerring certainty, also gives a stiffness almost equal to that of a solid iron bar, while by hanging the cables, with their planes inclining toward each other, a strong resistance is offered to lateral disturbances, and the almost solid inverted arch—which the cables themselves form—with their solid iron rods connecting to the floor offers the same resistance to vertical movements, thus providing against all the forces with which a bridge must battle. This surely entitles Mr. John A. Roebling, its architect and constructor, to a position in the front ranks of civil engineers.

In this bridge many small defects may have been developed in its thirty-seven years' use—some parts may have been made too light—if such have been developed in the taking of it down, it will probably be found that they are such as could have been replaced, as the bridge was so built that any part of it could have been got at and repaired if injured or renewed if requisite.

The bridge was subject to no greater vibrations than are generally observed in the wooden arch and truss bridges of same span.

It has often been sorely tried, sometimes when crowded with people viewing a boat race, and sudden rushes would be made from one side of the bridge to the other. I have heard from Mr. Roebling that he thought it was tested to half its strength.

The bridge is memorable also as being the first of a series of which the last is the great Brooklyn Bridge, now approaching completion.

In addition to my own personal knowledge relative to the construction of this bridge, I wish to acknowledge my indebtedness for valuable information in the preparation of this paper to:

Washington A. Roebling, of Brooklyn, New York.

Jonathan Rhule, of Phillipsburg, Pa., for long time foreman for Mr. John A. Roebling.

Wm. M. Lyon, Esq., and Wm. H. Everson, of Pittsburgh, Pa.

The editors of Pittsburgh *Gazette*, who kindly placed their old files at my disposal.

Reference was also had to:

Frederick Overman's work on "Mechanics."

Neville B. Craig's "Olden Time."

Appleton's Cyclopœdia of Applied Mechanics.

Day's Historical Collections of Pennsylvania.

And Mr. John A. Roebling's own report to the New York *Railroad Journal* in 1846.

TABLE OF DIMENSIONS OF THE MONONGAHELA SUSPENSION BRIDGE.

Length of bridge between abutments	feet	1,500
Number of spans		8
Length of each span	feet	188
Deflection of cables	"	14
Number of cables		2
Number of sections of cables		16
Diameter of cables	inches	4½
Number wires in each cable		750
Weight per foot of each cable	pounds	39
Weight of cables and wrapping	"	119,000
Length of the 16 cables	feet	3,036
Ultimate strength of the two cables		860
Aggregate weight of one span so far as supported by the cable with 100 head of cattle on it	tons	110
Tension of cable produced by dead load of bridge and 100 head of cattle on one span	tons	192
Weight of 100 head of cattle at 800 pounds	"	40
Tension resulting from it when at rest	"	70
Weight of four six-horse teams loaded with 104 bushels of coal each	tons	28
Tension resulting from it when at rest	"	49
Weight of superstructure of one span so far as supported by cables	tons	70
Tension of cables resulting from it	"	122
Section of anchor chains and connecting links	inches	36
Sections of pendulums	"	32

ENGINEERING SOCIETIES.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

May 16, 1883.

The Society met at 8 p. m., Vice-President Wm. H. Paine in the chair; John Bogart secretary.

A piece of the frame of the United States steam transport Maple Leaf, sunk in the St. John's River, Florida, April 1, 1864, and raised February, 1883, was presented, through J. Fras Le Baron, Esq., M. Am. Soc. C. E. The wood (pine) was in excellent condition. There were also presented interesting photographs from Capt, C. B. Sears, M. Am. Soc. C. E., Corps of Engineers, U. S. A., showing the construction of the hydraulic graders now in use by the Mississippi River Commission for grading caving banks previous to resetting.

Detailed announcements were made as to the Convention to be held at St. Paul and Minneapolis beginning June 19, 1883.

The special train from Chicago, Milwaukee & St. Paul Railway, will leave that city for St. Paul at 7:30 a. m. Monday June 18.

The paper recently published in Transactions "On the Increased Efficiency of Railways for the Transportation of Freight" was discussed by Mr. O. Chanute.

Mr. Chanute suggested that it was worth enquiring whether the diminished average miles, obtained from cars is an unmixed evil and whether there have not been changes in the methods of transporting business which, while requiring less movement of cars, yet added to economy of trade and convenience of customers, and also whether the diminished mileage may not be offset by decrease of empty mileage, and by savings effected to general business. Also that if expense can be saved to owners in the receiving or depositing of property, it enables them to pay a better freight rate.

The methods of transacting business connected with the transportation and handling of commodities have changed greatly during the past 20 years. It is worth investigating whether these changes, which are beneficial to the country at large, have not conduced to the diminished average movement of cars, and whether this diminished movement has not really added to the facilities for transacting business, and that if these facilities be cultivated it may be necessary to make corresponding reductions in freight charges.

Mr. Chanute also referred to the figures given by

Mr. Shinn, which show that a large percentage of freight cars run empty. It costs nearly as much to haul an empty car as a full one, and by designing and managing cars so that they can be loaded back, and having a sufficient number to enable them to wait for such back loads, empty mileage may probably be reduced.

He also referred to the economy likely to result from the establishment of large warehouses at terminal points.

He also, while agreeing with Mr. Shinn that there are serious defects in the present system of mileage charges, suggested some objections to the per diem charge which Mr. Shinn proposes to substitute.

First—That it may lead to a considerable increase in the mileage of empty cars.

Second—That there would be difficulty in following the per diem charge over the different roads over which the car passes so as to afford a check to the owner.

Third—The probable increased expense in keeping the accounts beyond the present system, with the probable necessity for the establishment of a car-clearing house.

Fourth—The opposition which will arise to the proposed change.

Fifth—The confusion and hardship likely to occur from changes of methods.

Mr. Chaunte suggested these objections, not as insuperable, but to show that there must be a well matured plan presented rather than merely the suggestion of a plan.

He also considered the charge of one dollar per day, proposed by Mr. Shinn, to be entirely too large, because it yields much more than the interest upon the cost, depreciation, and cost of repairs.

He presented figures showing the cost of the cars and of their maintenence upon the Erie and the Pennsylvania railroads, and from these figures drew the conclusion that a per diem charge of 25 or 30 cents per day would be a fair one.

The paper was also discussed by Messrs. Cooper, Forney, Emery, Hamilton and Shinn.

Mr. F. J. Cisneros, M. Am. Soc. C. E., who recently visited the Isthmus of Panama, presented an informal statement of the progress of the work upon the Panama Ship Canal. He stated that the purchase of the Panama Railroad by the Canal Company seemed to promise most excellent results, and suggested that proper methods in the management of the railroad and lower charges for both freight and passengers would certainly increase its revenue.

In reference to the canal, he said that the line had been completely staked, cross sections taken and the location made and stakes set for definite work for a large portion of the line. The line is entirely cleared and grubbed from kilometer 40 to the mouth of the Rio Grande, and is rapidly advancing at other points. The valley of the Chagres has been surveyed, and it has been found that the high water lines above the high dam will cover an area of about 6,750 acres, and that the volume of water stored will be about 1,000,000,000 cubic meters. Actual work upon the canal has been commenced at six points.

The contractors, Messrs. Slaven & Co., for dredging the canal from Colon have their first herculean dredge in place, and will commence work directly. The canal company has been working with two French machines at the rate of 1,000 cubic meters per day for each machine. The Franco-American Trading Company has contracted for the excavation of about 10 kiloms. of the canal beyond the Bay of Panama. Their machines are being built at Lockport. There are now about 6,500 men on the work, chiefly Jamaicans, Carthegenians and a few Martiniqueans.

Many dwelling-houses, machine shops, etc., have been constructed. The machinery is both French and American, and the eleven American excavators are working with great economy. Borings have been made along the whole line, and have extended to the bottom of the canal, giving in a general way the following results: From Colon to Kilom. 10, material easily dredged. From Mamey to Obispo, mostly clay with occasional seams of rock. From Obispo to Emperador about 7 kiloms. of hard trap of conglomerates. From Emperado to Paraiso, about 8 kiloms clay for about 15 metres, then indurated clay followed by schist and reaching rock near the bottom of the canal. From Paraiso to Pedro Miguel, 10 to 12 meters clay followed by rock. From Pedro Miguel to the sea, mostly clay and mud with the exception of a few seams of rock.

Considerable work has been done at the port of Colon, including the commencement of a breakwater.

Much money has been spent in the purchase of materials for the work, including excavators, dredging machines, and portable track. The company has ordered 14 American locomotives, of which 9 are now in service.

Hospitals have been erected at Panama, and the health of the laborers is very much better than has been generally understood.

ENGINEERS' CLUB OF PHILADELPHIA.

ROOMS, No. 1523 CHESTNUT ST., PHILADELPHIA, PA.

Record of Regular Meeting, April 21, 1883.

President Henry G. Morris in the chair; twenty-two members and two visitors present.

Mr. Percival Roberts, Jr., exhibited a turning from a cast steel roll. The dimensions of the roll, which was cast from open hearth steel, were about 30 inches by 5 feet 6 inches. The turning is 4 inches wide by 12 inches long, $\frac{1}{16}$ inch thick, showing the roll to have been very homogeneous and very tough for cast steel.

A communication from Mr. E. H. Talbott, Secretary National Exposition of Railway Appliances, requesting the co-operation of the Club in the proposed Department of Engineering Exhibits, was presented and discussed.

Record of Regular Meeting, May 5, 1883.

President Henry G. Morris in the chair; twenty-two members and two visitors present.

Mr. T. M. Cleemann was enabled to show, through the courtesy of Mr. W. W. Evans, of New York, a map and profile of the Southern Pacific Railroad in California, showing where it crosses the dried-up bed of a lake, being below the surface of the Pacific Ocean for 58 miles, and attaining a depth below said surface of 266 feet. At this point it skirts a deposit of salt from 6 to 24 inches in thickness. He also showed a number of photographs of the Tehachapi Pass on the same railroad, near San Fernando. In order to attain the summit with a sufficiently reduced grade, the line was "developed," advantage being taken of a conical hill to wind about it in the form of a helix, crossing itself, and continuing on its way with several meanderings. The Saint Gothard Railroad has several such helices, but they are cut in the solid rock. A similar location was made about 18 years ago in the Southern Pennsylvania Railroad, but it was not built. Another piece of interesting location was also exhibited, namely, the mountain division of the Western North Carolina Railroad, which shows great skill in fitting a line to the country.

Mr. George S. Strong described a new method of manufacture of corrugated boiler tubes.

Mr. E. F. Loiseau gave a sketch of the progress and condition of the manufacture of artificial fuels.

Mr. R. H. Sanders described a derrick used for hoisting material from a slate quarry by means of cable and bucket, and Mr. T. M. Cleemann noted a similar method pursued in the construction of a viaduct in Peru, 252 feet high, when the pieces were conveyed by a traveler to the pier.

Mr. C. G. Darrach continued his remarks with regard to the relative quality of water at the top and bottom of deep reservoirs, and discussed methods of meeting the difficulty encountered in the accumulation of impurities below the surface.

HOWARD MURPHY,
Secretary and Treasurer.

SURVEYING IN WEST VIRGINIA.

The portions of West Virginia lying away from the few thoroughfares of trade and travel are peopled by descendants of Indian fighters and trappers, who long before the Revolution penetrated the wilds and took up their abodes on river and creek bottom lands. These descendants, as the land has grown poorer from taking all off and putting nothing on, and from rapid increase of numbers, have been pushed by unyielding necessity to mountain clearings and mountain gorges, into which neither the knowledge of the things of this world nor of the other has penetrated. The habits and hardihood of their forefathers are their only inheritage, and long brass mounted rifles are their only heirlooms.

One day, after riding many miles along almost unfindable paths connecting one small clearing with another, with only green broom grass and briars, seemingly not able to support a sparrow comfortably, I remarked to my companion that I could not see how the people managed to live off such miserable land.

"Hold on stranger!" said a drawling voice from the bushes, and a long haired, half starved looking native lazily rose from the ground and stepped out into the path. He was rags from where one layer of clothing commenced on his shoulders to where it ended, half way down his legs. "Looks like you don't know much. I heered you say that. Now, lookee yer! I own all the land yer see hereabouts—nigh onter three hundred acres. You don't call that being poor, does yer?" And that evidently settled the matter to his satisfaction if not to ours.

After replying to a few scattering questions shot after us as he followed our horses, ranging in subject from the price of our boots to "What mought yer have in them boxes?" I inquired the way to our destination. He gave the stereotyped reply of the country: "Keep right 'long the main road and you'll get thar," but added no instructions as to how to distinguish a main road from a cow path.

SEEKING FOR A BOUNDARY.

My object was to find the proper boundary of a large tract of land, blanketed with titles, no two of which called for the same lines; for the surveyor of this part of the country was "hoss doctor," "physic man," "'squire," "onregular preacher" and "old saddle pockets," whose only interest in a deed was a *per diem* one contained in his usual query: "Whar does yer want the line run?" So they were consequently run to suit the taste and pocket of his employer, hacked, corners made, and courses and distances duly guessed at, slightly modified by compass and stepping. This had been his practice for over forty years, until lawyers got nearly all the land as fees for countless litigations, and a disgusted judge suggested from the bench "that as this court was going up pokey fishing, it was a good time for the regulators to tar the surveyor and smash his d——d compass," which, coming to his ears in time, resulted in a mob finding his cabin empty and Jacob's staff broken as signs of surrender.

After unraveling the main road mystery for a few miles beyond the penetrating power of the voice of the landed pauper, we reached a cabin with three or four log offshoots, accommodating as many generations, and bare of all surroundings excepting the crowd of inhabitants. After arranging to stay there, I at once went to work adjusting my transit for accurate work.

Men, women, buxom maids and children gathered round in concentrated wonder at "What the thing was fur."

"Stranger, Bob yer says that's a clock. Be it, mister?" said one. Another took a circuit about the main question: "Nate, yer think's he's got a power of smartness 'cause he's been down the river. He says it's a pictur' gallery? What does yer ask for a pictur?"

I explained that the transit box was my picture gallery, but I was in too big a hurry to take any on this trip. A youth suggested, and his idea was generally adopted, that because the telescope moved up and down "Hit was a pattern new trick fur squirillen." I held my peace, well knowing that more fun would come of it.

My companion was quite a distance off in a grove of beeches and sycamores with a sight pole, and the instrument was directed on him, the line of sight lying close by some large trees. I asked a young woman if she would like to take a look. After much coaxing and many assurances that it would not go off or otherwise hurt her, she ventured a look through the telescope.

"Well, I'm durned if that man hadn't come right this way. Looks like he were standin' lookin' in t'other end," and she looked over the telescope to see if he was there. Seeing the trees in front, she said: "Why, stranger, it sees right clear through 'em, don't it?" I replied yes, that was what it was for; that I was going to survey the land; that the instrument was much better than the old fashioned compass the old doctor had, as I could see through anything with it, and not have to cut trees or bushes out of the way.

TERRIBLY ASTOUNDED.

"Trees and all?" she asked, in great wonder.

"Yes," I said.

"Clothes and all?" she said, with some alarm.

"Yes," I replied, with solemn assurance, "clothes and all—any amount of them."

She backed off at this and soon had all the women huddled around her, to whom she earnestly communicated what she had seen and what I had told her. Two or three separated from the group and told their husbands. The joke was too good for me to stand. I rapidly wheeled the telescope on the ground and looked through it. Screeches of all kinds filled the air. They grabbed their clothes, clasped their hands, folded their arms, threw their aprons over their heads, doubled up, sat down, rolled over, whirled like tops, yelled "Don't!" "Yer ornary man!" or shook their fists; and then, it occurring to one woman to run, they all followed like a flock of sheep, each trying to get under cover of the other, looking backward to see if the thing was on them, tripping and tumbling into the cabins, barring doors and windows after them.

My fun was soon over. The men began to gather clubs and "rocks." There was no time to hesitate. I drew my revolver and stood firmly on the defensive, rapidly explained the joke and invited one and all to take a look. Soon loud laughs followed, and every one knew the secret of the transit and reason of the stampede.

The man who had agreed to furnish "a bit and bed" went into his cabin to explain. He soon returned and said a little excitedly:

"Stranger, I am fretted, but you'd better git to onest. The woman folk is powerful mad, and they's gitten the kittles ready bilen. I tried to settle it for you, but it warn't no use. My old woman says, 'Derned if I shall pull an inyun or peel a 'tater fur a man spyen a my calikes!'—*Detroit Free Press.*

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JOHN A. ROEBLING, C. E.

The subject of this sketch was born on June 12, 1806, in the city of Mülhausen, Prussia. He took the usual academical course, and completed his education as a civil engineer at the Royal Polytechnical School in Berlin. As a student his career is said to have been unusually brilliant.

Mr. Roebling's first practical experience in the profession he had selected was upon certain governmental works in Westphalia, three years being spent in that duty.

In 1831 Mr. Roebling came to the United States, and for several years devoted himself to the improving of a tract of land near Pittsburgh, Pa., and to the attempted founding of a town. Tiring of this uncongenial class of work, he soon sought and obtained a position as assistant engineer on the slackwater navigation of the Beaver River, a tributary of the Ohio; from this work he was transferred to the Big Sandy and Beaver Canal, and later still, was engaged in the construction of a feeder to the Pennsylvania Canal, from the upper portion of the Alleghany River. A survey for a route across the Alleghany Mountains, for the Pennsylvania State Railroad, between Harrisburg and Pittsburgh next occupied the time of the young engineer for a space of about three years.

Having completed the State surveys intrusted to his care, Mr. Roebling turned his attention to the manufacture of wire rope, an, until then, untried industry in the United States. He had been investigating this subject for some years previously, and as a result of this study he devised new and improved machinery for his first works, which were located near Pittsburgh, Pa.

Probably his first application of wire cable to structural purposes was in 1844. At that time the wooden aqueduct carrying the Pennsylvania Canal across the Alleghany River became so unsafe as to require renewal; and Mr. Roebling designed and contracted for the erection of a new aqueduct, the trunk constructed of wood as before, but supported upon a pair of continuous wire cables, each 7 in. in diameter, and forming in all seven spans of 162 ft. each.

In 1844 while the aqueduct just mentioned was still under construction, the wooden bridge across the Monongahela at Pittsburgh was destroyed by fire, and at once replaced by a suspension bridge from Mr. Roebling's design. This structure had eight spans of 188 ft. each, and there were two cables each 4½ in. in diameter.

In 1848 Mr. Roebling contracted for the erection of four suspension aqueducts for the Delaware & Hudson Canal Co., with dimensions as follows: Lackawaxen aqueduct, two spans of 115 ft. each, and two 7-in. wire cables; Delaware, four spans of 134 ft. each, two 8-in. cables; High Falls, one 145 ft. span, two 8½-in. cables; Neversink, one 170 ft. span, two 9½-in. cables. While engaged upon these contracts Mr. Roebling removed his manufactory of wire rope from Western Pennsylvania to Trenton, N. J., founding the establishment now so well known as "Roebling Son's."

As early as 1846, the problem of bridging the Niagara River for railroad purposes was being investigated by the subject of our sketch. It was at first proposed to haul the cars across by horses, no engine to pass over. Upon this basis, Mr. Roebling, in the year mentioned, offered to construct a railway suspension bridge, with one track, two carriage ways and two footways for the sum of $180,000, but Col. Chas. Ellet, Jr., who was his competitor, obtained the contract for the erection of the first Niagara Suspension Bridge.

It was soon after determined by the railroad authorities to replace this first bridge by one adapted to the passage of engines as well as cars, and Mr. John A. Roebling having been appointed Chief Engineer, commenced operations in 1851, and in March 1855 completed the work assigned him.

The span of this famous bridge is 825 ft., with the track at an elevation of 250 ft. above the water in the Niagara River. The four cables each contain 3,569 No. 9 iron wires. The trusses introduced into this structure for stiffening purposes were the marked features in its construction. Many other departures from older methods were here used, notably the continuous wrapping of the cable with wire, as a substitute for iron bands or simple coils of wire. The machine used for this purpose was the invention of the builder of the bridge.

While the building of the Niagara bridge was in progress, Mr. Roebling designed a wire suspension bridge for the then projected Lexington & Southern Railroad, at its crossing of the Kentucky River. The span was 1,224 ft. The towers and anchorages were built and most of the wire delivered, when financial embarrassment caused the company to abandon the work. These same towers were recently utilized by Chas. Shaler Smith, C. E., in the erection of the truss railroad bridge now spanning the Kentucky River at that point.

In 1856 Mr. Roebling commenced laying the foundations of the Cincinnati and Covington Suspension Bridge across the Ohio River, after having as early as 1846 made plans for a bridge at the same point; his first design differing from the one finally put into execution in having two spans, with a tower in the middle of the stream. The financial crash of 1857, and then the rebellion of 1861, delayed work upon this structure until 1863, when Mr. R. resumed operations and finished the bridge in 1867.

The principal dimensions of the Cincinnati and Covington bridge are as follows: Main span between centers of towers, 1,057 ft.; side spans, from center of towers to abutments, 281 ft.; Cincinnati approach, 341 ft.; Covington approach, 292 ft.; total length of bridge, 2,252 ft. The two cables are each 12⅓ in. in diameter, and each one contains 5,200 No. 9 iron wires. The weight of each span between the towers is 1,500 tons, and the ultimate strength of each cable 4,212 tons. The roadway is 20 ft. wide between the cables, with two footways of 7 ft. each outside the line of cables.

Between 1858 and 1860 the Alleghany Suspension bridge was built at Pittsburgh, with a total length of 1,030 ft., divided into two spans of 344 ft. each and two side spans of 171 ft. each. The floor is 40 ft. wide. There are four cables, two 7 in. in diameter and two 4 in. in diameter. The towers are cast iron.

The last and crowning professional work of Mr. Roebling's life was the design and commencement of work upon the already celebrated bridge now spanning the East River, and uniting the cities of New York and Brooklyn. It was upon this work, and in the direct line of professional duty, that Mr. Roebling met with the accident that cost him his life. His right leg was crushed by the shock of a ferry-boat against the fender-piles on which he was standing, directing some of his workmen, and his death followed on July 22, 1869. His name will ever be inseparably connected with the work upon which he was last engaged, and his memory will be honored with a prouder monument than usually falls to mortal lot.

WHAT RAILROADS HAVE DONE FOR TEXAS.

In 1842 there were less than 100,000 people in the entire State of Texas, and, excepting at San Antonio and on the Rio Grande, not a house west of Austin. Within the last ten years the population has more than doubled, now numbering over 2,000,000 souls.

This astonishing and rapid increase can only be ascribed to the wonderful railroad development in the last very few years, within its borders: 7,000 miles of iron road now band the fertile plains and arid wastes as wells of the Lone Star State; constructed at a cost of nearly $200,000,000. The Texas Central, from North to South; the Missouri Pacific, stretching 868 miles across the northern portion of the State; and the Sunset route, connecting New Orleans with the Rio Grande and California by way of the seaboard and southern tier of counties; and these main arteries of travel are again laced together in every direction by a multitude of transverse roads and lateral branches.

In Northwestern Texas where one year ago there were only two or three mere hamlets, there are now half a dozen flourishing towns with over 10,000 inhabitants and doing a business in sale of merchandise of $4,000,000 per annum. The existence of these communities is directly due to the advent of the Texas & Pacific Railway, opened only twelve months ago. In 1880 the acreage in cultivation in twenty-two counties contiguous to this road, west of the town of Weatherford, was 99,834. At the close of the year 1882 this area was increased to 200,000 acres. In Taylor and Fisher counties the valuation of property for 1882 exceeded the valuation for 1881 200 per cent. and in Nolan County the increase was over 250 per cent.

During the past year the growth of the cattle and sheep interest has been simply immense, and the State will net $13,500,000 this year from the increase of her sheep farms alone. Here again the railroad has brought wealth and encouraged the investment of capital, for these cattle are now sent to the Eastern market by rail; the old-time "drive" is a thing of the past.

This prosperity and advance is the work practically of the last decade, and since what may be called the completion of the main railroad systems; who will now deny the supreme value of the iron way as a developer and builder-up of communities?

THE BOTH CLAM-SHELL DREDGING BUCKET.

From photographs of the bucket, and the accompanying description by the inventor, A. C. Both, C. E., of Portland, Me., this arrangement seems to leave little room for improvement. The compact design, the arrangement of parts, and the attention paid to remedying the defects of older inventions, prove it to be the work of an expert, a result of the close and intelligent attention of one who knew practically where the fault lay, and how it could be overcome.

Without an illustration we cannot better describe this particular bucket than by noting the points claimed as peculiar to itself, and which claims the illustration seems to carry out.

1. Increased and equal closing power during entire cut.

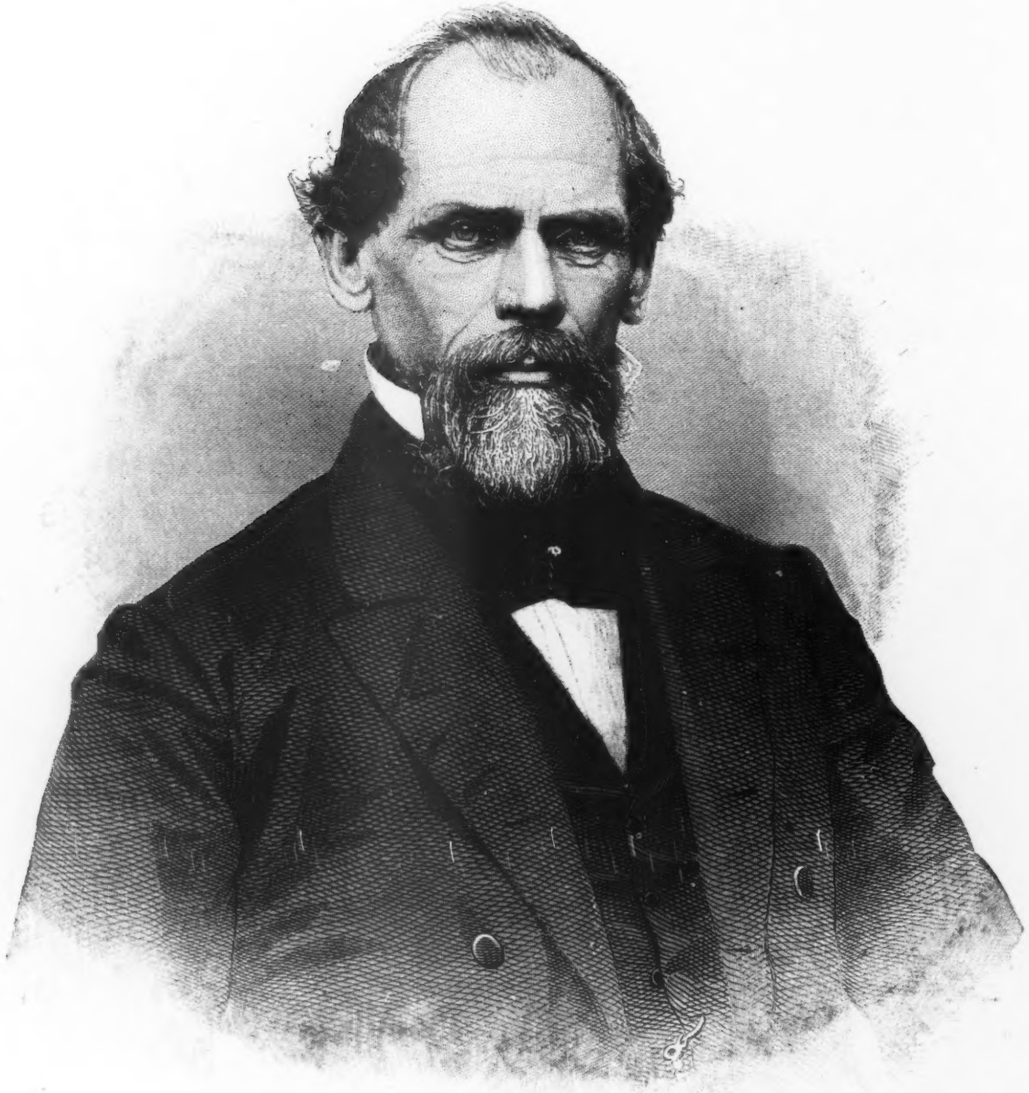
2. Wide opening of the shell, with a clear cut from beginning to end without scraping or compressing material. (A three-yard bucket opens 12 ft.)

3. Entire prevention of wear on main shaft or chain wheel, by inclosing the whole shaft in a cylindrical casting, which carries the chain wheels and contains several gallons of oil, with stuffing boxes at the ends to keep out grit, etc.

4. The bucket cuts a long flat strip from surface and *standing on bottom* will fill the bucket with the one cut.

5. No suction.

6. The bucket frame not being subjected to wear, will hold all the moving parts in true rel-



John A. Roebling

ative position, and prevent undue strains and breaks.

Every part is made of steel or hammered wrought-iron, and the arrangement of parts is such that any one can be readily removed without interfering with the others.

The 3-yard bucket opens 12 ft., is 13 ft. 6 in. high when closed, and weighs complete 13,600 lbs.

THE BRIDGE OPENED TO THE PUBLIC.

May 24, 1883, will be an always-to-be-remembered day in the city annals of New York and Brooklyn, for on that day, in strict accordance with the published programme, promptly on time, without a jar or accident, the greatest suspension bridge in the world was formally declared finished and open to public travel.

The day was a glorious one, and the gathered crowd, such as only can be seen in New York—the President of the United States, members of his cabinet, the Governor of the State and his staff, the Mayors of New York and Brooklyn, and their respective municipal assistants, of aldermen and city councils, all did honor to the occasion. The Seventh Regiment of the National Guard, together with the military of Brooklyn and 900 New York policemen did guard and escort duty. The Hon. Abram S. Hewitt was the orator of the day, and after briefly sketching the history of the great work completed, and eulogizing the engineering staff "who have thus made humanity itself their debtor," spoke of the bridge itself as cheap at the price, and destined to work wonders for the future prosperity of the two cities it linked together. Mr. Hewitt was followed by the Rev. Dr. Richard S. Storrs in an eloquent address. Mayor Low of Brooklyn and Mayor Edson of New York formally accepted the bridge in behalf of their respective cities.

The exhibition of fireworks with which the ceremony was closed lasted from 8 to 9 p. m., and in quantity and variety and exceptionally favorable site for display was the grandest ever seen on our continent.

We have one adverse criticism to make, however, upon the issue of invitations to parties residing outside of the cities of New York and Brooklyn; and this refers especially to the cards sent to the non-resident members of the American Society of Civil Engineers—a broad expanse of pasteboard in elegant script and all the glory of Tiffany's art, stated that "The Trustees of the New York and Brooklyn Bridge request the honor of the presence of * * * * * * * at the opening ceremonies;" but a failure to inclose in these envelopes the "blue" or "white" ticket admitting to the bridge made the journey of many a civil engineer from neighboring towns a fruitless and disappointing one. The card of invitation was simply an empty honor, entitling the bearer to elbow his way as best he could through the dense mob of "outsiders." The only apology we can offer for the management in this case is the usual confusion attending preliminaries of any event of similar magnitude. We understand that some of the neglected ones did obtain admission by an exhibit of the formal cardboard; but if this was the rule—and it was expected that the large cards were to be carried about—a messenger-boy should have been likewise inclosed to assist in that service; the envelope was large enough.

BOOK NOTICES.

PRACTICAL CARPENTRY, a guide to the correct working and laying out of all kinds of carpenter's and joiner's work; by Mr. F. T. Hodgson, Editor of the *Builder and Woodworker*. This book, the author wishes it understood, is not intended to take the place of the larger and more exhaustive works on the subject, but is issued as a "handy-book" to the American workman. It is small in size, low in cost, and any carpenter can afford to put it in a corner of his tool-chest and can study it with profit. Plain in expression, and abundantly illustrated, it presents and solves all practical problems likely to arise in the daily practice of the craft for which it is designed. It is from the press of the Industrial Publication Company, price $1.

PERSONAL.

HENRY FINK has resigned as Vice-President and business manager of the Norfolk and Western Railroad.

SAMUEL W. FERGUSON of Mississippi has been appointed by the President to suceeed Captain James B. Eads on the Mississippi River Commission.

PRESIDENT NICKERSON, of the Mexican Central Railway, was honored with a banquet in Mexico on May 16, given by the Governor of the Federal district and the City Council. General Diaz was present.

A. A. ROBINSON, Chief Engineer of the Atchison, Topeka & Santa Fe Railroad, is to be made Assistant General Manager of that road from June 1. It is understood that he will still retain charge of the Engineering Department.

H. S. MCELWAIN died in Amsterdam, N. Y., May 22, aged 76. He was for many years Superintendent of the old Utica and Schenectady R. R.; and is said to have introduced gravel-ballasting, and to have been the "first man" to lay T-rail in the United States.

WILLIAM MASON died at Taunton, Mass., May 21, aged 76. He was probably best known as a builder of locomotives, he having started his now extensive works in 1852. He was one of the ablest inventors New England ever produced. He invented in 1837 the self-acting mule for spinning cotton, and made many improvements on locomotive engines.

F. DE FUNIAK, late General Manager of the Louisville & Nashville Railroad, and President of the Pensacola and Atlantic Railroad, departed for Carlsbad, Austria, on May 16. Mr. Funiak was for many years Chief Engineer of the first-named road, and succeeded ALBERT FINK as General Manager. He retires for personal reasons.

HENRY VILLARD, the controlling spirit in the North Pacific Railroad and the Oregon Navigation Company, and, with Vanderbilt and Gould, one of the leading railroad magnates in the United States, is the son of GUSTAV HILGARD, formerly President of the Supreme Court in Munich, and nephew of JULIUS HILGARD, the Superintendent of the U. S. Coast Survey. Mr. VILLARD is about 49 years old, and came to this country in 1853. He went West, and, meeting HORACE GREELEY while that journalist was making his famous trip across the continent, he was engaged as a correspondent, and made his *nom de plume* of "Villard" so favorably known that he ended by discarding his own name in its favor. The era of wild speculation ending in 1873 offered him greater opportunities for money making than a newspaper career, and, abandoning the latter, he went back to Europe and laid before the rich merchants of Germany and Holland the advantages presented by the heavy rates of interest paid by American securities. He was intrusted with the investment of vast sums, and carried out his part of the contract with so much judgment that his name is yet a tower of strength among foreign capitalists. His comparatively late battle with the North Pacific Railroad people and his victory are too well known to need mention here.

WALTER J. MORRIS, Civil Engineer, late engineer of the Broadway Underground Railway, died of pneumonia on the evening of the 16th inst, at St. Luke's Hopital, this city. Mr. MORRIS was born in Richmond, Va., 47 years ago, and from an early age he was engaged in engineering enterprises. One of his first surveys, while yet a boy, was to lay out the town of Manchester on the James River, opposite Richmond. He was engaged in the location and construction of the Iron Mountain R. R., Mo., and finally became its chief engineer. He was city engineer of Paducah, Ky., and during the war was chief of engineers on Gen. Albert Sidney Johnstons staff; then of Gen. Polk's Corps, and later of Gen. Dick Taylor's department. At the close of the rebellion Mr. MORRIS went to South America and assumed a prominent part under General MEIGS in building two lines of railway for the Peruvian government, in the Andes. It is said that that government now owes him two and one-half per cent of $27,000,000 for his services as engineer, contractor, etc. From South America he went to Turkey, and took part in certain breech-loading rifle negotiations, and afterward he surveyed a railway for Turkey through the Balkans. Then he came to New York, projected the Broadway underground railway, was the engineer of the South ferry and Direct Transit enterprise in Brooklyn; also of the Huntsville, New Orleans and Western Texas road. Just before his death the Turkish government was negotiating with him to resume charge of his old railway system in Turkey. The remains were taken to Richmond, Va., for interment.

CORRESPONDENCE.

NORFOLK SEWERAGE.

NORFOLK, Va., May 22, 1883.

EDITOR ENGINEERING NEWS:

SIR: Your correspondent "C. F. J." of Wilkesbarre, Pa., misinforms you in reference to the correctness of the formula used for determining the size of pipe in the Norfolk system of sewerage. He states that the diameter of a pipe will be less than $\frac{1}{32}$ of an inch when the length of the line is 1,500 ft., the fall 1 in 200, the discharge to be 5 gallons per hour to each person, 6 persons to each house and one house every 25 ft.; using the formula $D = \left(\frac{m^2}{1450s}\right)^{\frac{1}{5}}$, where m = cubic ft. per *second* and S = slope in fraction of a foot.

It will be evident to your correspondent that the amount of refuse to be provided for in the case in question is .5 gal. per sec. Reducing this to cubic feet, we get .066 cu. ft. per sec.; squaring this we have .004356 or m^2, $1{,}450S = 7.25$; $.004356 \div 7.25 = .0006$; $\sqrt[5]{.0006} = .2268$ ft. or approximating 3″ in diameter—considerable difference between that and $\frac{1}{32}$ of an inch.

Our friend's conclusion in regard to the probability of the supposed error being in making m = cubic ft. per *second*—suggesting that it should be cubic ft. per *minute*—was evidently too hastily assumed. I would refer him to the theories and experiments of Darcy and Weisbach, and would advise him to read the valuable correspondence upon this subject published in Vol. IV. ENGINEERING NEWS.

In the separate system of sewerage we do not use smaller pipe than the 6″ for laterals, and as we limit the use of laterals there is of course no use for a calculation of their size. It is only necessary to calculate the size of a pipe in cases where there are a number of laterals to enter that pipe—as in the case of mains and sub-mains. Yours respectfully,

RICHARD LAMB.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SOC. C. E.

(*Continued from page* 220.)

XXXIV.—TYRONE, PA.

Tyrone, Pennsylvania, on the North fork of the Juniata River, is on uneven ground, on the foothills of the Allegheny Mountains.

Settled in 1850, it was incorporated a city in 1856.

Water-works were built by a private company in 1870, taking the supply from Sinking Spring Run, a mountain stream with a water shed of 15 square miles.

A dam across the stream, 3 ft. high and 20 ft. long, at 114 ft. above the lowest part of the city, diverts the water into a 10-in. pipe which supplies the town. The pipe first laid was of wood; this, after twelve years' service, has not given satisfaction, and is being replaced with cast iron.

There are 4 miles of 10 to 4 in. pipe in use, with 25 fire hydrants, 20 gates and 400 taps. The city pays $2 per year for each hydrant. Service pipes are of plain or galvanized wrought iron, with some of lead.

The population in 1880 was 2,678. The daily consumption is not known.

No financial statistics are furnished.

C. Guyer is the President, A. A. Stevens the Secretary and Cary H. Dieffenbough, the Superintendent.

EXCAVATION OF THE SUBMARINE TUNNEL BETWEEN CALAIS AND DOVER.*

Now that the question of a tunnel between France and England seems about to enter in a fair way of being realized, I believe that the description of a new method for executing the works, and which are essentially mechanical, automatic and offering a great economy, would be interesting to the members of your society, and I submit this notice, which has been already read before the Institution of Mechanical Engineers in Leeds, and the meeting of the British Association in Southampton.

Without going into any matters referring to the geology of the two countries, we shall take it for granted that there is a bank of chalk between Calais and Dover—that it is regular and uniform in its contexture, completely impermeable to water, and soft enough to be easily cut or planed down by tools of ordinary sharpness.

A trial has been made with a perforating machine similar to that which we are about to describe in a layer of argillaceous chalk that is quite similar in its nature to the Rouen chalk-bed between Calais and Dover. A cylindrical hole of 7 ft. in diameter was perforated with it, and the work was advanced at the rate of one meter (39 in.) per hour.

A gallery of 7 ft. in diameter and the length of the tunnel could be made with two such perforators, starting from the extremities, in about 666 days, or twenty-two months.

The whole work could be thus executed in less than four years, for not more than two years would be required to widen the gallery, and give it the section of a large subterranean tunnel for double track, similar to those of Mont Cenis or St. Gothard, which took not less than ten years for their building. But, knowing the nature of chalk as we do now, from the borings made at Dover and at Sangatte, we would not be forced to restrict ourselves to a gallery of 7 ft. diameter, to be afterward enlarged. There is nothing to prevent the tunnel from being excavated in a circular section of 36 English feet in diameter, and there would be no danger of the walls of such a cylinder falling in.

We will therefore suppose that a perforator which can attack the greatest diameter of the tunnel, and advance at the rate of a yard an hour is at work. The machine would give us some 117 cubic yards of rubbish to be taken away. Fifty per cent. may be added to this figure by the natural increase, etc., and we shall thus have some 250 tons of calcareous matter to be removed per hour.

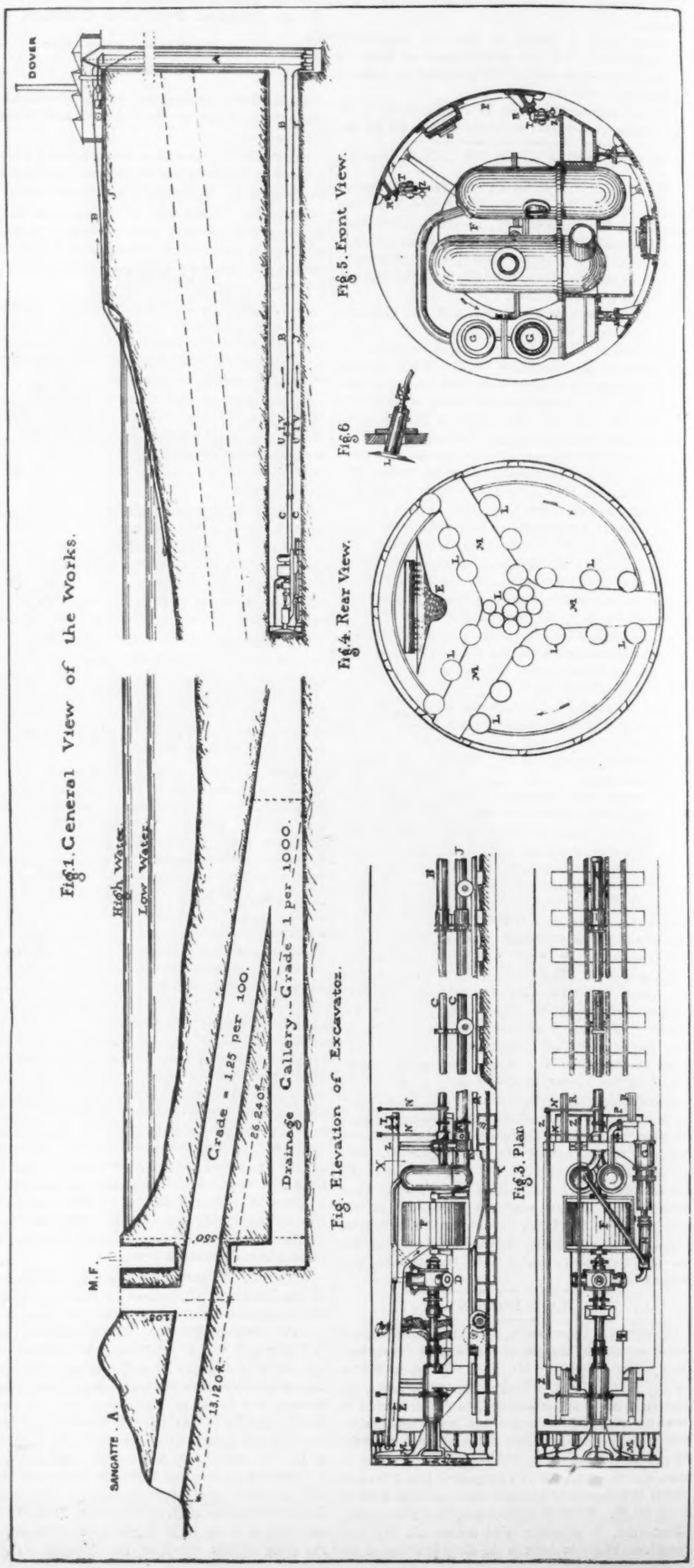
If we suppose this rubbish taken away by the ordinary systems of wagons drawn by horses, or locomotives, etc., we find that 83 wagons will be necessary for the transport of the 250 tons (3 tons per wagon). Each wagon would have to be filled in 44 seconds, and allowing ten wagons to a train, one of the latter could be sent off every seven minutes. The wagons would then have to be raised to the top of a shaft 393 feet in depth. This would be equivalent to removing of 6,000 tons of excavated matter per diem from the same shaft—a quantity double of that from any of our coal shafts. But this is not all. The masonry facing of the tunnel (35 inches in depth) would require a supply of 32 cubic yards per hour of material for each running yard, and the wagons would have to be sent away on other tracks.

The execution of the work would therefore be very difficult if the ordinary system would be adopted to build the facing at the same time as the withdrawal of the cuttings. I shall now describe a method which would do away, in my opinion, with all the work requiring the use of wagons. It is based on an hydraulic apparatus which will at the same time work the perforating machine, carry off the rubbish from the face of the work to the surface, and throw them into a sink-hole from which they may be afterward pumped.

I shall take it, however, as if the tunnel was to be excavated for one-half its length (ten miles) at 393 ft. below the level of the sea, and as if the perforation and withdrawal of the matter should be done at a distance of ten miles from the point of departure.

A powerful steam engine, with pumps to raise the sea-water and subject it to enormous pressure in accumulators would be placed beside the opening of the vertical shaft *A* (Fig. 1). This pressure would be 38 atmospheres, for instance, and by adding to it 12 atmospheres resulting from the difference between the sea level and that of the tunnel, we could dispose of a power of 50 atmospheres at the bottom of the shaft, the same as is usually employed for machines of this kind. The feed pipe *B*, bringing this water under a pressure of 50 atmospheres to the bottom of the shaft and the head of the perforator, would have to be lengthened as the machine advanced, and this would be facilitated by the use of a pipe *C*, with a telescope joint, and having a free run of

*New hydraulic system proposed by Mr. Crampton, of London. Specially translated for ENGINEERING NEWS from Compte Rendu des Travaux de la Société des Ingénieurs Civils



24 yards, so as to have only one stoppage in the 24 hours.

The perforating machine (Figs. 2 to 5) would be actuated by a hydraulic motor *D*, working directly without any gear. The chalk detritus would be taken up by a series of buckets, and deposited in an inclined leader *E*, on which the water that has been used for working the perforator is thrown. This water as it falls down the leader carries off the loose matter into a drum revolving at a certain speed. Here it is soon converted into a state of slush or silt. The volume of water used for the hydraulic motor might be about three times the weight of the *débris*. The fine grained matter is rapidly dissolved after passing through the revolving drum, and a cream or mush is formed, which after passing through the mesher of the metallic sieve forming the vertical tide of the drum, is carried off by the ordinary pump *G*, worked by the hydraulic motors *H*; it is next sent through the discharge pipe *J* (Fig. 7) to the bottom of the shaft *A*, or else forced up vertically to the sea if deemed best.

The pumps *G* are fixed on the frame of the perforatory machine, and the hydraulic motors *H* are worked by water under a pressure of 50 atmospheres and supplied by the feed pipe *B*. The discharge pipe *J* is furnished with an apparatus with telescope joint as the one spoken of above. The two telescope lengths are connected with one another and subject to the same movements.

There are two valves, *U V*, between the telescope and the principal pipe. When the compressing piston is at full length, the valves are shut and the jointure *I* between them is disconnected, the telescope is then put in motion, forwarded on the compressing cylinder by the opening of a small cock *K* which connects the compressing cylinder with a vacuum chamber. The water in the compressing cylinder will rush into the chamber and the telescope will be driven above the cylinder and along the machine by the pressure of the air behind it. The space left between the valves *U V* is filled by an over length of pipe with valve attached. The small cock *K* is closed, the valves *U V* are opened and the work of the perforator is resumed.

Whenever it is necessary to bring back the machine, as for instance to change the disk knives, the ratchet and pinion wheel will be stopped by means of a hydraulic piston, which is not shown in the cut.

The creamy stuff will be forced back by pumps along the perforated tunnel to the bottom of the shaft, and thence by the pumps to surface of soil, etc. It will be seen that the tunnel is perfectly free between the shaft and the perforator, with the exception of the room taken by the two pipes. The work of facing the tunnel then becomes very easy, for there will be no other carriage of matters on the rails and no other descents or ascents in the vertical shaft than that of the masonry for facing the arch. We have already seen that these cartings would not be more than one-fifth of the matter there would be in the wagons if the ordinary methods were used—in other words, four-fifths of the rubbish would pass away in pipes, instead of being put in wagons.

A few details as to the power of the machines, the diameter of the feed and discharge pipes, and a few other data relative to hydraulic machines will be in place.

CUTTING THE CHALK.

The machine used for cutting the chalk is very simple in construction. It is shown by cuts 2 to 6 and arranged for cutting a gallery of 7 feet in diameter. It consists of a certain number of small revolving metallic disks *D* placed at an inclined angle, fixed on a large perforating shield *H*, and arranged to work at any determined speed. Each disk takes away about 2 millimeters in thickness (0.079 inch) of chalk at every revolution and of a width of one-fourth the diameter of the disk. The disks are arranged to work continuously, and to take away only a quantity of chalk in proportion to the thickness and width of the cut. The disks (Fig. 6) revolve freely on their axes *A*, and as they cut into the chalk to only about a quarter of their diameter they turn on themselves in an opposite direction to that of the shield, and they thus hollow out grooves in the chalk. The sharp side of the knife changes continually and thus wears but little, in fact it never requires to be sharpened as it does not get blunted. I have used a perforator on chalk at the rate of 16 ft. an hour without any damage to the edge of the disk knives.

I found from numerous experiments that not more than 2½ horse power was required for excavating one cubic metre of chalk per hour, and piercing a tunnel of 34 feet diameter would only require a motive power of 340 horses.

The pressure of the water on the surface of the telescope joint, on the one side, and that from behind the slush on the other, will always drive the machine automatically forward, but it becomes necessary to provide a device for controling the speed. There are several simple ways of doing this; Fig. 2 shows one consisting of a gearing with screw and pinion acting on a ratchet.

Seventy-two disks would be required for a chalk wall of thirty-four feet diameter. If the shield *H* makes ten revolutions per minute we shall have a velocity of 330 metres per minute at the extreme circumference, or about seventeen feet per second, which is quite within working limits. It is readily understood that the disks revolving at different velocities, those at the extremity of the circle will have much more to do than those near the centre. It has been found that in cutting chalk the work of the disks will be equal whatever may be their velocities. The cross supports on which the machine moves and the ratchet, by means of which its advance is regulated, are made of pieces of suitable lengths, and when one gets free in the rear, it is immediately taken and placed in front. This is done, as shown in the transverse section of the machine (Fig. 5), by means of two arms, *FF* (Figs. 3 and 5), which are mounted on the same line as the principal shaft behind the machine. These arms are brought down and screwed to the cross-beam *E*, on which are a few lengths of rails, *R*, and the ratchet *S*.

A small hydraulic machine, etc., can be used to make the arms and cross-pieces take the position indicated by dots when they revolve, and when the cross-piece with its accessories are placed on two small carriages *H H*, which move on rollers over the sleepers *G*. These carriages have bearers and hooks on which the rails are placed. The arms are then unscrewed and the carriages with the cross-pieces, etc., are pushed forward by hand, or moved by gravity on the sleepers *G* to the front of the machine, where the cross-piece *K* is taken up by arms or levers exactly like the others, and placed in the required position at the end of the gallery.

REDUCING CHALK DEBRIS TO PULP.

I set up, some years ago, a small apparatus that produced, however, a large quantity of calcareous cream, such as is used in cement manufactories. It was simply a cylindrical drum, 47 inches in diameter, 31 inches in length, inside, and making 32 revolutions per minute. One of the vertical sides was composed of a strong metallic grating, but having an opening in centre of some 14 inches.

The chalky *débris* and the water enter through this opening and the particles of chalk are soon dissolved, producing a creamy mass of greater or less consistence—it passes out through the meshes along with the water into a reservoir from whence it may be pumped. I have reduced 21 tons of chalk by this little apparatus in less than an hour. Fig. 2 represents a drum with the dimensions stated, placed in a tunnel of 7 feet diameter. It is only a simple question of calculation to find the sizes of the cylindrical drums necessary to excavate the tunnel at greatest diameter of 34 feet. Two drums 81 inches in diameter and 81 inches in length would be quite sufficient. I can affirm that 0.65 of one horse power would reduce a cubic metre of chalk into the creamy state in one hour, and that the total power for the entire tunnel would be equal to that of a machine of 83 horse-power.

CARRYING THE CREAM TO THE SHAFT OPENING.

I made numerous experiments with pipes of small diameters to measure the excess friction of the chalky liquid as compared with pure water. I may say that I found that a mixture of chalk and water in equal proportions had 14 per cent. more frictional resistance than pure water. The resistance is reduced to 3¾ per cent. when water is double the weight of the chalk, and is reduced to 2½ per cent. when there are 3 parts of water to 1 of chalk. I think, therefore, that the proportions should be 1 of chalk to 3 of water by weight, or by volume 1 of chalk to 6 of water. I also found that the chalk cream should be sent through the pipes with a velocity of at least 18 in. per second, or else the particles may form resistant bodies. With a perforator working at the rate of 136 cubic metres per hour on one metre in length we should want 816 cubic metres of water per hour, and this would be supplied by a pipe of 13 inches diameter under a pressure of 50 atmospheres. The water would run at a speed of about 9 feet per second. The power developed would be equivalent to 1,377 horse in front of the perforator —337 horse power being given by the pressure of the sea water alone—the complementary 1,040 being supplied by the pumps driving the water under accumulators. The mixture to be removed is composed of: 2 cubic metres of chalk per minute, 12.40 cubic metres of water or a total of 14.45 cubic metres.

A large horizontal discharge pipe 19 in. in diameter would carry the mass to the bottom of the shaft, 16 kilometers away. The total pressure requisite to drive it would be 64 meters, or 4 per kilometer—this represents a power of 224 horses.

TAKING AWAY THE MASS FROM BOTTOM OF SHAFT TO SURFACE.

We should require 340 horse power for cutting the chalk, 85 for the reduction of the chalk into a creamy mass, and 224 for bringing it in pipes ten miles to shaft entrance, a total of 649 horse power. But as we have 1,377 horse power at disposal we shall have more than sufficient, even if the hydraulic motors should only give 50 per cent. of work. Additional power would be required to raise the cream from bottom of shaft to surface, and this we have calculated at 525 horse power. The total power would then be 1.565 horse. The cream might be driven through a single pipe from face of work to the surface, but much more powerful machines would be necessary. In case of an inclined profile that would facilitate the drawing off the water, the sea-level pressure would be alone sufficient, but the supply of water would have to be very much larger and the diameter of feed pipe at least twenty-inches. If the tunnel was cut at an inclination of $\frac{1}{1000}$, the cream would flow off by gravity to bottom of shaft. The proportion of water to chalk would be 13 to 1, and then the cream would flow as easily as water in an open canal or lead. The pipe of 26 inches, with a pressure of 12 atmospheres, would supply upward of 35 cubic yards of water per minute at front of work, and at a speed of 300 feet per minute, would represent 800 horse power. More than double the quantity of silt would have to be raised, and the pumps would have only 950 horse power, instead of 1,565, as under high-pressure.

Air could be sent to the workmen along with the water under high-pressure, and would serve to ventilate the tunnel. The materials for facing could be sent by electric motors or compressed air. The power required for the hydraulic system is not one-third of what would be required for machines with compressed air and having trains drawn by locomotives, and their contents then lifted to surface.

At the meeting of the Paris civil engineers the machine was exhibited by the inventor, who also proved that with 40 revolutions per minute of the head of perforator, a block of chalk could be cut at the rate of 78 in. per hour. When a belt and steam power was applied and revolutions raised to 120 per minute, the progress was 16 ft. per hour.

TESTS OF RIVETED JOINTS FOR BOILER-WORK.*

BY CHARLES HENRY MOBERLY, M. INST. C. E.

Having to design the joints for some steam boilers which the author's firm had to construct, in the spring of 1881, he decided to be guided by the following, as the most suitable data of which he had any knowledge:

1. Some double-riveted lap joints of $\frac{7}{16}$ in. Landore S plates, with Landore steel rivets tested by Mr. Kirkaldy for the author's firm in 1879, giving results as under:

Breaking strength of the solid plate per square inch = 25.85 tons.

Breaking strength of the plate in the joint per square inch of original area fractured = 23.21 tons.

Shearing strength of rivets in the joints per square inch = 19.4 tons.

2. Professor Kennedy's experiments on steel-riveted joints, made for the Research Committee of the Institution of Mechanical Engineers,† from which the following is taken as a fair conclusion:

Breaking strength of the solid plate per square inch = 29 tons.

Breaking strength of the plate in the joint per square inch of original area fractured = 33 tons.

Shearing strength of rivets in the joints per square inch = 22 tons.

The discrepancy between these two sets of conclusions is considerable, but not greater, perhaps, than is continually met with, as yet, in experiments on riveted steel-plate joints. The joint designed for the boilers in question was a double-riveted butt-joint with double covers, the inside cover being $\frac{7}{16}$ in. thick, and the outside one $\frac{9}{16}$ in. thick, to bear the calking, as shown in Fig. 1, Plate 8, viz.:

Pitch of rivets, 3.775 in.

Distance between rows of rivets, 1.5 in.

From center of rivets to edge of plate, 1.125 in.

Lap, 3.75 in.

Diameter of rivets, ¾-in. nominal.

" punch, $\frac{13}{16}$-in. = 0.125 in.

" $\frac{13}{16} + \frac{1}{8} \times \frac{9}{16} = 0.925$ in.

Mean diameter of holes = ½ (0.8125 + 0.925) = 0.8687 in., say 0.87 in. Net length between the holes along the straight line = 3.775 — 0.87 = 2.905 in. for each pitch; and along zigzag line = 2 (2.41 — 0.87) = 3.08 in.

Area of one rivet $\frac{13}{16}$ in. in diameter = 0.5185 sq. in.; hence rivet area to resist shearing = 4 × 0.5185 = 2.074 sq. in. per pitch. Net area of the plate between the holes along the straight line = $\frac{7}{16}$ × 2.905 = 1.634 sq. in., and area of solid plate per pitch = $\frac{9}{16}$ × 3.775 = 2.123 sq. in.

* From Other Selected Papers of the Institution of Civil Engineers.

† Institution of Mechanical Engineers. Proceedings, 1881 p. 205.

REPORT No. 2.—SUMMARY OF THE RESULTS OF EXPERIMENTS TO ASCERTAIN THE ELASTIC AND ULTIMATE TENSILE STRENGTH AND QUALITY OF THE STEEL IN SIX RIVETED JOINTS; ALSO OF SIX STEEL RIVETS, RECEIVED FROM MESSRS. EASTON & ANDERSON.

PLATES—ALL CUT LENGTHWAY.

Specimens out of Riveted Joint.	Test No.	Thickness.	Stress. Elastic per square inch.	Stress. Ultimate per square inch.	Ratio of elastic to ultimate.	Contraction of area at fracture.	Stress per square inch of fractured area.	Extension-set in five inches. At 50,000 lbs. per sq. in.	Extension-set in five inches. At 60,000 lbs. per sq. in.	Extension-set in five inches. Ultimate.	Appearance of fracture.
	P.	In.	Lbs. Tons.	Lbs. Tons.	Per cent.	Per cent.	Lbs.	Per cent.	Per cent.	Per cent.	
P 2,125 A	2,126	.53	38,300	68,455	55.0	48.6	133,386	4.52	9.64	36.4	
	2,127	.55	36,200	66,620	54.3	48.5	129,473	5.48	12.04	36.8	
	Mean		37,250 = 16.6	67,537 = 30.2	54.6	48.5	131,429	5.00	10.84	36.6	
P 2,135 D	2,136	.56	35.800	67,440	53.0	42.1	116,561	5.08	11.38	35.6	
	2,157	.54	35.800	67,320	53.1	49.6	133,648	5.22	11.46	36.8	
	Mean		35.800 = 16.0	67,380 = 30.1	53.0	45.8	125,104	5.15	11.42	36.2	
P 2,143 G	2,144	.55	37,800	69,920	54.0	46.0	129,699	3.18	6.98	34.2	
	2,145	.53	36,700	68,290	53.7	46.9	128,802	4.76	10.48	36.0	
	Mean		37,250 = 16.6	69,105 = 30.8	53.8	46.4	129,250	3.97	8.73	35.1	
P 2,128 B	2,129	.54	35,800	66,835	53.5	49.3	131,957	4.96	11.38	35.2	
	2,130	.55	35,300	66.660	52.9	49.1	130,189	5.34	12.38	35.8	
	Mean		35.575 = 15.8	66,747 = 29.7	53.2	49.2	131,073	5.15	11.88	35.5	
P 2,137 E	2,138	.55	35,400	67,415	52.5	46.4	125,901	4.64	10.04	35.6	
	2,139	.54	35,200	67,105	52.4	47 9	128,855	5.02	11.10	36.4	
	Mean		35.300 = 15.7	67,260 = 30.0	52.4	47.1	127,428	4.83	10.57	36.0	
P 2,146 H	2,148	.55	37,800	69,990	54.0	41.8	120,279	3.48	7.06	33.6	
	2,147	.54	36,500	67 235	54.2	52.7	142,378	5.10	11.42	37.2	
	Mean		37,150 = 16.5	68,612 = 30.6	54.1	47.2	131,328	4.29	9.24	35.4	
	Tot. mean		36,387 = 16.2	67,773 = 30.3	53.5	47.3	129,268	4.73	10.38	35.8	

RIVETS.

Nominal size of rivets.	Test No.	Original Diameter	Original Area.	Stress. Elastic per square inch.	Stress. Ultimate per square inch.	Ratio of elastic to ultimate.	Fractured. Diameter	Fractured. Area	Fractured. Difference. Ar.	Fractured. Difference. P.c.	Stress per square inch of fractured area.	Extension.	Appearance of fracture.
	P.	In. trd.	Sq. in.	Lbs. Tons.	Lbs. Tons.	Per ct.	In.	Per ct.			Lbs.		
¾-in. diameter.	2,154	.504	.200	37,500	66,120	56.7	.32	.080	.120	60.0	165,300	Too short for ascertaining the extension.	Silky.
	2,153	"	"	37,400	65,880	56.7	.33	.085	.115	57.5	155,011		
	2,155	"	"	37,400	65,000	57.4	.31	.075	.125	62.5	173,493		
	2,152	"	"	36,800	64,510	57.0	.31	.075	.125	62.5	172,028		
	2,157	"	"	36,200	64,320	56.2	.31	.075	.125	62.5	171,520		
	2,156	"	"	34.500	60,280	57.2	.30	.071	.129	64.5	169,802		
	Mean			36,633 = 16.3	64,302 = 28.7	56.9				61.6	167,859		

Made for Messrs. Easton & Anderson, Erith Iron Works, Erith, Kent. (Signed) DAVID KIRKALDY, 99 Southwark Street, London, S. E., June 30, 1881.

The breaking strength of the joint came out as follows:

By tests of 5-16-in plate joints.

Solid plate..... $2.123 \times 25.85 = 54\ 88$ tons.
Through holes..... $1.634 \times 23.21 = 37.93$ "
Shearing rivets..... $2.074 \times 19.40 = 40.24$ "

Least ratio of strength..... $\frac{37.93}{54.88} = 0.69$ "

By Professor Kennedy's data.

Solid plate..... $2.123 \times 27 = 61.57$ tons.
Through holes..... $1\ 634 \times 33 = 53.92$ "
Shearing rivets..... $2.074 \times 22 = 45.63$ "

Least ratio of strength..... $\frac{45.63}{61.57} = 0.74$ "

These results are all with punched and unannealed plates; and as it is generally admitted that the strength of joints is increased by drilling the holes and annealing the plates—and either and both operations could be resorted to if necessary—the author considered the joint, as designed, satisfactory for the purpose for which it was intended. But, having regard to the uncertainty still attaching to the strength of steel-riveted joints for boilers, it seemed desirable to have some tests made, and sample joints were prepared accordingly. The result of these tests was so different from what was expected, and so unsatisfactory otherwise, that further experiments were made in order to determine the proper proportion for these particular joints. All these tests, taken together, make a fairly complete series for the form of joint of $\frac{5}{16}$ inch steel plates in question.

In order to determine the rules which should regulate the proportions of all descriptions of riveted joints, a sufficient number of results of tests must be compared. Although a good many such results have, from time to time, been made public, many of them are incomplete, and more appear to be required before safe conclusions can be deduced for practice.

The author offers the present account of tests as a contribution toward such a collection. The plates tested were all of Landore S quality, 9-16 inch thick, and the rivets were of Landore rivet steel. A few tests of single-riveted lap joints for the circular seams of the same boilers were made together with the others, and will be included in this account. The whole of the tests were carried out by Mr. D. Kirkaldy, copies of whose reports are appended (numbered 1 to 7).

The first set of specimens consisted of nine joints (marked *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, and *I*), and six rivets (Appendix, Reports Nos. 1, 2 and 3). Joints A, B and C had all the holes punched as already described and shown in Fig. 1. Joints *D*, *E* and *F* had the holes in the covers punched, but those in the joint-plates were punched with a $\frac{1}{8}$-inch punch, and drilled out to 13-16 inch in diameter, as shown in Fig. 2. Joints *G*, *H* and *I* also had the covers punched, while the holes in the joint-plates were punched with a $\frac{5}{8}$-inch punch, and drilled out to $\frac{3}{4}$ inch diameter, so that the larger side of the holes was barely cleaned out by the drill, as shown in Fig. 3.

It was intended to have all the joints shaped like *B*, *E* and *H*, Fig. 4; but Mr. Kirkaldy objected to this form, because he considered the results would not be reliable, and wished to have them all shaped like *A*. *D* and *G*, Fig. 5. It was finally arranged to try both forms, and the joints were shaped accordingly, as shown in Figs. 4 and 5.

Finding that the plate broke in all these joints, the remaining three, *C*, *F* and *I*, were used to ascertain the shearing strength of the rivets by drilling out four rivets, and leaving three only on each side, as shown in Fig. 6 (Report No. 3).

The riveting in all these experimental joints was done by a hydraulic riveter, with an accumulator placed next to the machine, and the pressures given are those of the accumulator. In the nine joints now under consideration this pressure was 35 tons.

The plates were not annealed in any of the joints tested.

It will be most convenient to consider the results of the rivet shearing tests first (Reports Nos. 2 and 3).

The rivets happened to be rather bare in diameter, so that, the same rivets being used in all cases, those for the $\frac{1}{16}$-inch holes had to be longer than would otherwise have been the case. Thus the rivets for the $\frac{1}{16}$-inch holes were upset much more than those for the $\frac{3}{4}$-inch holes.

The tensile breaking strain (Report No. 2) was 28.7 tons per square inch, while the shearing strains were:

	Tons per sq. inch.
In *C*, with holes punched 13-16th inch	23.8
In *F*, " " " $\frac{5}{8}$ inch, and drilled out to 13-16th-inch	24.2
In *I*, with holes punched $\frac{5}{8}$ inch, and drilled out to $\frac{3}{4}$-inch	25.8
Mean shearing strain	24.6

In these cases, therefore, the shearing strain was $\frac{24.6}{28.7} \times 100 = 85.7$ per cent. of the tensile strain. But it will be observed that the lowest tensile in strength Report No. 2 is considerably below all the others; it may, therefore, be more fair to take the mean of the four middle tests only, omitting the highest as well as the lowest. This gives the tensile strength = 29 tons per square inch; and the shearing strength becomes $\frac{24.6}{29} \times 100 = 84.82$ per cent. of the tensile strength. Thus the shearing strength of the rivets may be considered to be 85 per cent. of their tensile strength.

The breaking of joints *A*, *B*, *D*, *E*, *G*, and *H* must be considered next. Here it may be explained that all the joints for these experiments were riveted up for the full width of the plates, as shown in dotted lines, and caulked on the edges as they would be in boiler work; they were afterward shaped to the required form.

Report No. 1 gives the results of the tests, and shows the lines of fracture in each case, and, with the assistance of Figs. 1 to 5 and the particulars of the holes already given, the length of the line of fracture, the original sectional area along that line, and the original sectional area of rivets sheared is obtained.

1. Joints *A* and *B*, with $\frac{1}{16}$-inch holes, punched in the ordinary way.

A broke through the rivet holes with 117.5 tons; length of fracture = 9.24 inches; area of fracture = $9.24 \times 0.54 = 5$ square inches; strength of plate per square inch of fracture = $\frac{117.5}{5} = 23.5$ tons = $\frac{23.5}{30.2} = 0.778$ of solid plate; ratio of strength of joint to solid plate = 64.19 per cent.

B broke through the rivet-holes with 128.8 tons; length of fracture = 10.27 inches; area of fracture = $10.27 \times 0.545 = 5.6$ square inches; strength of plate per square inch of fracture = $\frac{128.8}{5.6} = 23$ tons = $\frac{23}{29.7} = 0.774$ of solid plate; ratio of strength of joint given in report No. 1 is 60.02 per cent.

But this is not the correct ratio of the strength of the joint, when used in a boiler, because it may fairly be assumed that the fracture would have continued in a zigzag line in the continuous joint instead of running along the straight line of rivets from the two outer rivets to the edge, as it did in this case. The specimen being 13.22 inches wide, the length of fracture along the zigzag line would have been 10.77 inches, instead of 10.27 inches, and its breaking strength would have been $\frac{10.77}{10.27} \times 128.8 = 135$ tons, making the strain per square inch of the gross area of joint = $\frac{135}{7.2} = 18.75$ tons. Hence the ratio of strength of the joint becomes $\frac{18.75}{29.7} \times 100 = 63.13$ per cent., which corresponds fairly with the result of joint *A*.

2. Joints *D* and *E*, with holes punched $\frac{5}{8}$ inch, and drilled out to $\frac{1}{16}$ inch in diameter.

D broke with 117.7 tons, by shearing one rivet and breaking along a line of fracture = 6.72 inches; area of fracture = $6.72 \times 0.545 = 3.66$ square inches, sheared area of one rivet = $2 \times 1.515 = 1.03$ square inch; shearing strain of ditto $= 1.03 \times 24.6 = 25.34$ tons; leaving $117.7 - 25.34 = 92.36$ tons to break 3.66 square inches of plate;

hence, strength of plate per square inch of fracture = $\frac{92.36}{8.66}$ = 25.23 tons = $\frac{25.23}{30.1}$ = 0.838 of solid plate; ratio of strength of joint to solid plate = 63.83 per cent., as per Report No. 1.

But it must be observed that all the four half rivets were more or less displaced sideways, though they were not entirely forced out of the joint. The holes were, of course, elongated. The half-hole on the right side measured $\frac{1}{2}$ inch, and the hole in which the rivet had been sheared measured $\frac{1}{8}$ inch full lengthways, after testing, as shown in Fig. 8.

E broke with 144.3 tons, by shearing one rivet and breaking along a line of fracture = 9.2 inches; area of fracture = 9.2 × 0.545 = 5 square inches; shearing strain of one rivet = 25.34 tons; leaving 144.3 — 25.34 = 118.96 tons to break 5 square inches of plate; hence, strength of plate per square inch of fracture = $\frac{118.96}{5}$ = 23.79 tons = $\frac{23.79}{30}$ = 0.793 of solid plate; ratio of strength of joint to solid plate = 66.7 per cent. This joint is remarkable, because the second half was nearly broken through at the same time that the first half gave way altogether.

3. Joints *G* and *H*, with holes punched $\frac{5}{8}$ inch, and drilled out to $\frac{3}{4}$ inch in diameter.

G broke with 114.3 tons, by shearing two rivets and breaking along a line of fracture = 4.82 inches; area of fracture = 4.82 × 0.54 = 2.6 square inches; sheared area of two rivets = 4 × 0.441 = 1.764 square inches; shearing strain of ditto = 1.764 × 24.6 = 43.4 tons; leaving 114.3 — 43.4 = 70.9 tons to break 2.6 square inches of plate; hence, strength of plate per square inch of fracture = $\frac{70.9}{2.6}$ = 27.27 tons = $\frac{27.27}{30.8}$ = 0.885 of solid plate; ratio of strength of joint to solid plate = 61.02 per cent., as per Report No. 1.

But the four half-rivets were again displaced sideways, and the holes elongated, as in joint *D*. The measurement of the elongated holes, after testing, was: Half-hole on left $\frac{11}{16}$ inch (half-rivet nearly sheared); half-hole on right $\frac{7}{8}$ inch; hole in which the rivet was sheared on left $\frac{1}{8}$ inch bare, and on right 1 inch full, as shown in Fig. 9.

H broke with 142.8 tons, by shearing two rivets and breaking along a line of fracture = 7.47 inches; area of fracture = 7.47 × 0.545 = 4.07 square inches; shearing strain of two rivets = 43.4 tons; leaving 142.8 — 43.4 = 99.4 tons to break 4.07 inches of plate; hence, strength of plate per square inch of fracture = $\frac{99.4}{4.07}$ = 24.42 tons = $\frac{24.42}{30.6}$ = 0.798 of solid plate; ratio of strength of joint to solid plate = 64.71 per cent.

Before drawing any conclusions it appeared desirable to try the effect of drilling the holes in the joint-plates out of the solid, the covers being punched as before.

Two joints, *K* and *L*, were therefore prepared in this way, the arrangement of rivets being the same as before. A further difference was also introduced in the form of the specimens, which were shaped as in Fig. 7 (Report No. 4). The holes were drilled $\frac{11}{16}$ inch in diameter. The pressure used in riveting was 35 tons, as before.

K broke with 128.6 tons, by shearing one rivet and breaking along a line of fracture = 7.3 inches; area of fracture = 7.3×0.56 = 4.09 square inches; shearing strain of one rivet = 25.34 tons, as in *D*; leaving 128·6 — 25.34 = 103.26 tons to break 4.09 square inches of plate; hence, strength of plate per square inch of fracture = $\frac{103.26}{4.09}$ = 25.26 tons = $\frac{30.3}{25.25}$ = 0.833 of solid plate; ratio of strength of joint to solid plate = 66.9 per cent.

L broke with 130.7 tons, by shearing two rivets and breaking along a line of fracture = 5.55 inches; area of fracture = 5.55×0.56 = 3.1 square inches; shearing strain of two rivets = 50.68 tons; leaving 130.7 — 50.68 = 80.02 tons to break 3.1 square inches of plate; hence, strength of plate per square inch of fracture $\frac{80.02}{3.1}$ = 25.81 tons = $\frac{25.81}{30}$ = 0 86 of solid plate; ratio of strength of joint to solid plate = 66.6 per cent.

The results may now be considered with reference to—

I. The effect of the form of the specimen.

II. The effect of the mode of making the holes.

III. The general arrangement of proportions of the joint.

I. The effect of the form of the specimen may be judged by a comparison of *A*, *D*, and *G*, Fig. 5, with *B*, *E*, *H*, Fig. 4, as shown in the following table:

Mark of joint	*A*	*D*	*G*	*B*	*E*	*H*
Breaking-strain of section per square inch in tons	23.5	25.23	27.27	23.00	23.79	24.42
Ratio of same to that of solid plate	0.778	0.838	0.885	0.774	0.793	0.798
Ratio of strength of joint to that of solid plate, per cent.	64.19	63.83	61.02	63.13	66.70	64.71

Comparing joints *A* and *B*, which not only were riveted, but also broke in the same way, namely, through the rivet-holes only, it will be seen that the strength per square inch of the plate, along the line of the fracture, as well as the ratio of this strength to that of the solid plate, were practically identical in both cases. The ratio of the strength of the joint is slightly greater in *A* than in *B*, but the difference is not greater than may fairly be expected between similar test pieces. But as a correction has to be applied to the direct result obtained from *B*, it is fair to infer that the form of *A* gives a more reliable result than the form of *B*. *D* and *E*, which were riveted in the same way, give more discordant results. As regards the strength of the section and the ratio this to that of the solid plate, *E* compares very well with *B* and *A*. The ratio of strength of the joint is, however, different. In *D* the strength of the solid plate (30.1 tons per square inch) was practically the same as in *E* (30 tons per square inch), but the strength of the plate along the line of fracture appears to be 0-838 of that of the solid plate in *D*, compared with the ratios 0.778, 0.774, and 0.793 in *A*, *B*, and *E*. The line of fracture in *D* passes behind the half-rivet on the left side, and to the inside of the one on the right side of the joint (Fig. 8). It is clear that the right hand half-rivet must have been forced out of place, so as to allow the parts of the broken plate to separate, by part of the strain applied to break the joint; but as the half-rivet was not sheared, it is impossible to say how much strain it bore, though this must, of course, have been less than the strain that would have sheared it.

(TO BE CONTINUED.)

HEAT FROM THE SUN.

The Mount Whitney observations show the sun to be hotter than was supposed. The heat received at the earth's surface is probably more by one-half than was estimated by Herschel and Pouillet, and even materially exceeds the values assigned by more recent investigators. It would in one year melt a crust of ice over the whole sunward half of the earth six hundred feet thick. This is, of course, a statement in very round numbers. The scientific phrase would be that the sun's vertical energy could raise the the temperature of one gram of distilled water three degrees Centigrade per minute for each centimeter of the earth's surface nominally exposed.

Having supplied us with an increased amount of heat, the Mount Whitney experiments also favor us with new figures of intenser cold The estimates of Herschel of Pouillet made the temperature of space 224° below the zero of Fahrenheit. The new results carry it down nearly to the calculations for the absolute zero, the absence of all heat, say minus 450° F. To the non-scientific mind the distinction betweeen such far down temperatures is not unlike that between the pains of rheumatism and those of gout—the first being as from a thumbscrew twisted to the last point of human endurance, the gout giving one turn more.

Further, it appears that the direct heating power of the sun cannot raise a thermometer quite 50° F. above its surroundings whatever they may be. If we suppose the whole globe a thermometer and without an atmosphere the sun could only heat it fifty degrees above the cold of space, leaving it at about minus 400° F. under full sunshine. The internal heat of the earth may be disregarded in these calculations. It seems paradoxical to say that if the atmosphere were removed from the earth its surface would receive more heat and yet be much colder. But this is a fact of the same kind as our experience in ascending a mountain. The atmosphere does indeed cut off a great deal of heat, but on the other hand it keeps a great deal of that which it permits to pass through. When the air is heated up to its retaining capacity an "equilibrium" is established.

To illustrate: let us imagine a large, empty, windowless hall, with two doors partially obstructed by Centennial turnstiles, one for entry and one for exit. A procession of one hundred persons enters per minute. At first there is abundant room; few want to come out. At the end of the second or third minute perhaps only three people are leaving for one hundred arriving. After a longer interval the number of departing guests is much greater. At last the hall is crowded to its utmost capacity, and if we still suppose one hundred per minute entering, it is absolutely certain that one hundred per minute must be getting out. This final condition is one which we may call equilibrium. If the turnstiles of Centennial pattern record their turnings, we can ascertain exactly how many people are in the hall at any moment. Now to apply the illustration to heat-bearing rays entering our atmosphere, we may suppose that nearly all reach the soil through radiation; but ninety per cent. go out through the regular exit of "convection;" nine per cent. squeezes back through the turnstile by which they entered—"radiation;" and one per cent. climb out through the chimney of "conduction." It follows that by merely regulating the turnstiles, by modifying this capacity for selecting and holding rays of certain wave-lengths, atmospheres could be constructed which would keep the planet Mercury cool or the far-off Neptune comfortably warm. Here is a hint for romancers who wish to plant their *dramatis personæ* in some other world.

The Allegheny and Mount Whitney observations firmly establish the fact that the sun is blue. The particular shade of color which it has, if viewed without intervening atmosphere, may be laid down as that on the border of the blue near the green, about where the line *F* appears in the spectrum. Sad to say, this is not an "æsthetic" hue; it is more like that referred to in one of Southey's poems: "You could almost smell brimstone, their breath was so blue, for he painted the devils so well."—*William C. Wyckoff in Harper's Magazine for June.*

NEWS OF THE WEEK.

THE AUSTIN, MANKATO & ST. CLOUD R. R. CO. elected recently three heavy Minnesota capitalists in its directory and work is to be commenced at once.

THE MANITOBA & NORTHWESTERN is to construct its line to Minnedosia this season.

THE CHICAGO, ST. PAUL & NORTHERN PACIFIC R. R. Co. was organized at Madison (Wis.) on May 21. The road is to run from Geneva, Wis., to Superior City. It will have two branches, from Geneva to Milwaukee and from Necedah to Tierce County. The main line will be 352 miles long, the branches combined 189 miles.

THE PHILA. & BALTIMORE R. R.—The Baltimore & Ohio R. R. advertise until June 10 for proposals to construct the new line between Baltimore and Philadelphia.

THE CANADIAN PACIFIC R. R.—W C. VanHorne, General Manager, says that they expect to reach the Rocky Mountains by August next. 1,500 miles of main line and 30 miles of branches are now completed and in operation, leaving 1,100 miles yet to build. The road so far cost about $16,000 per mile.

THE CHICAGO R. R. EXPOSITION.—The managers announce that all the area (500,000 sq. ft.) at their disposal has been taken up. The storm on Monday blew down thirteen sheds, the damage is about $1,000, and the accident will cause no delay in the opening.

THE AMER. INSTITUTE OF MINING ENGINEERS are promised a cordial reception by the citizens of Roanoke, Va. $2,000 has already been subscribed to the entertainment fund.

THE FLORIDA SHIP CANAL.—It is reported that Senator Windom has refused the offer of the vice-president's position, for the reason that there is very grave doubt about the purpose of the company ever to construct a canal. The cost would be enormous, put down at $40,000,000, and the revenue from the completed work small.

THE DECATUR AND WEST TEXAS R. R., will be chartered to run from Decatur through Jack and Young and into Throckmorton County.

CHEEK!—The following was issued by the Central Labor Unions of New York and Brooklyn: *To the Working People of the Cities of New York and Brooklyn:*

Despite the protests of the New York and Brooklyn Central Labor Unions and the trade and labor unions attached to them; despite the protests of the posts of the G. A. R. and the Board of Aldermen of New York City, the trustees of the Brooklyn Bridge have decided to open the bridge on May 24, the sixty-fourth anniversary of the birthday of Queen Victoria.

It is not necessary now to give reasons why the bridge should not be opened on that day; sufficient to know that it is intended to be a direct insult to American labor and to the gallant men who flew to arms at the call of duty to uphold the honor of the American flag.

We ask all good men and women in both cities to remember this latest insult of the would-be aristocratic element in our midst; we ask them not to assist, by their presence, at the opening of the bridge. CENTRAL LABOR UNION, New York.
CENTRAL LABOR UNION, Brooklyn.

CONTRACT AWARDED on May 15 to John S. Wolf & Co., of Ottumwa, Ia., for the construction of

the Duluth and Iron Range Railroad from Agate Bay to Vermillion Lake.

THE NORTHERN PACIFIC COMPANY has let a contract for building the Western Wisconsin Division from Superior City to Ashland, 60 miles. This will close the gap between the Northern Pacific and the Wisconsin Central.

A NEW PENNSYLVANIA RAILROAD LINE is projected from Easton *via* Bangor to Scranton, Pa. It is in the interest of the Pennsylvania Central Railroad.

THE LEHIGH VALLEY RAILROAD is locating a new line between Wilkesbarre and Scranton, Pa. The Lackawanna Company is also looking up a line between the same points.

THE PENNSYLVANIA RAILROAD COMPANY is considering the construction of a road between Ligonier, in Westmoreland County, and York, in York County, Pa. This will save distance between Pittsburgh and Philadelphia.

HEAN'S INLET CRIB.—Duluth, Minnesota, is to have one of Bates & Hean's improved inlets for her 18-inch suction. It is claimed that this inlet will not clog with anchor ice, and that it gives the maximum straining surface with the minimum of cost, and will not get out of repair.

THE ROANOKE WATER-WORKS are incapable of supplying the present demand, need extension and remodeling.

UNION CITY PA., WATER-WORKS will be finished next week.

THE B. & O. NEW ROAD TO CONNELLSVILLE. May 20.—J. L. Randolph, Chf. Eng. B. & O. R. R., was in Washington, Pa., to-day, preparing for the early completion of the Hempfield extension to Connellsville.

A CABLE TRAMWAY UP PIKE'S PEAK is promised this summer, provided that Secretary Teller gives right of way over the government reservation. The line will start at Manitou, 14,200 ft. from the summit.

THE ENGINEER'S CLUB OF MINNESOTA. The Civil Engineers of St. Paul and Minneapolis have just organized a club under the above name. Andrew Rinker, City Engineer, was elected President; W. De la Barre, Vice-Prest., and Prof. W. A. Pike, Secretary and Treasurer.

COLEMAN (TEXAS) COURT-HOUSE to be built, to cost $20,000.

NEW BRIDGE OVER THE ARKANSAS RIVER. May 15.—The Atlantic & Pacific R. R. Co., has just completed the bridge at Tulsa, Indian Territory, over the Arkansas River; total length, 1,400 ft. John E. Thomes is the Chief Engineer of the road.

THE DRIVEN WELL.—The contest between the farmers and the owners of the driven-well patent, to which public attention was recently directed by Judge Shiras' decision against the patentee, in Iowa, is one of the great legal battles of the West. In the State of Indiana alone there are 50,000 of these wells, for each one of which a royalty of $10 is demanded, and it is said that ex-Senator McDonald, whose ambition points toward the White House, has endangered his political popularity among the Democratic farmers by acting as attorney for the patentee. The interests involved are so great that the legal status of the controversy is especially interesting. At the recent hearing in Iowa, Judge Nelson, of the United States Circuit Court of Minnesota, and Judge Love, of the United States Circuit Court for the Northern District of Iowa, sat with Judge Shiras. Judge Love concurred in Judge Shiras' decision and Judge Nelson dissented. The appeal will not bring these cases before the Supreme Court of the United States for the first time. When the hearing in Iowa began, an appeal taken by the farmers from a decision made by Judge Gresham, of Indiana (now Postmaster-General), was pending in Washington, the case being that of Wahl against Hine. Only eight of the Supreme Court Justices sat at the hearing of that appeal. The Court was equally divided, four Justices being on one side and four on the other, so that the Supreme Court must try again. An appeal from the New Jersey District will probably be reached before the appeal which will go up from Iowa. In the meantime the patentee's application for an injunction prohibiting the Indiana farmers from using their wells has been denied. The conclusions of fact found by Judge Shiras are these: That Col. Green, in 1861, being then in command of the Seventy-sixth Regiment of New York Infantry, put his method of driving wells into public use for the benefit of his regiment, thereby abandoning his invention to the public; and that his invention was in open and public use, with his knowledge and acquiescence, for more than four years before he applied for a patent thereon. In these four years the public acquired rights through the open and uninterupted use of the discovery. Judge Shiras holds that it necessarily follows from these conclusions of fact that both the original and the reissued letters-patent are invalid and void.—*N. Y. Times.*

SAN JACINTO CANAL.—It is said that a company will soon be formed at Houston, Tex., to build a canal for drinking and hydraulic purposes to San Jacinto River. The canal is to be twenty-eight miles long, and is to cost $280,000. Several companies stand ready to build cotton mills when the canal is completed.

NEW BRIDGE.—One is in contemplation at Weatogue, in the town of Simsbury, over the Farmington River, (Conn.)

HOW JAY GOULD BOUGHT THE WORLD.—Mr. Jay Gould having sold out the New York *World* to Mr. Joseph Pulitzer, a reporter for that paper inquired of him on Saturday as to why he went into the newspaper business, and why he went out of it, with the following result:

"What, Mr. Gould, prompted you to dispose of your interest in the concern?"

"A large number of reasons, but the principal one was that I never intended to have the paper, and got it more by accident than design—almost against my desire. The way of it was this: In the summer of 1878 or 1879 I met Mr. Tom Scott, of the Pennsylvania railroad, in Switzerland—in Berne. Mr. Scott was very much depressed and broken up—financially, physical and mentally. I felt a profound sympathy for him. He asked me as a favor to take his Texas Pacific railroad off his hands, and I concluded to do so. In arranging the details Mr. Scott appealed to me to include the *World* in the transaction. He owned it absolutely. I cared nothing about it, but finally yielded, and that was the origin of the purchase. It was really a mere accident."

"But it is generally supposed, Mr. Gould, that you have a fancy for newspapers, and have interests in several other newspapers?"

"That is utterly untrue. I don't own a single share of stock in any newspaper in the country. I never cared anything about the *World* while I had it. It never occurred to me to use it for any personal or political purpose. It was simply an accidental trade of mine. I never interferred with its conduct in any form, its principles were invariably opposed to mine. I am a Republican; Mr. Hurlbert is a Democrat. He is a gentleman of great independence and character and of high honor. I never interfered with his management. I sometimes did not even see him in months. I don't think I have seen him now for the last three months. In fact, the best evidence of this is that the paper, as a matter of fact, never did reflect either my sentiments or my interests, and yet I never interfered. Take for instance, the tariff question. My every interest is in protection. Protection is the basis of all our national interests, our national industries, our national prosperity; yet I did not care, I did not bother. I did not interfere in the least when Mr. Hurlbert advocated free trade."

BRIDGE OVER THE KANKAKEE RIVER, ILL.—May 19.—The contract for an iron highway bridge over the Kankakee River, at Wilmington, Ill., has just been let to the Pittsburgh Bridge Co. Cost, $17,421.

THE STORM KING BRIDGE.—May 22.—The promoters of and objectors to this scheme had a hearing before the Governor to-day. The plan proposed is not made plain, though it was claimed that a railroad suspension bridge of 2,000 ft. span was practicable. Ex-mayor Judson, of Albany, and others protested against any bridge as an obstruction to navigation. It is believed that the Governor will veto the bill.

DES MOINES (IA.) WATER-WORKS.—The Water-Works Company at Des Moines, Ia., have never yet been able to get a sufficient supply of good water, and Gen. W. Sooy Smith & Son are now at work on plans for increasing the supply by means of filter galleries in the gravel bed lying along the Raccoon River. The work is under the care of Chester B. Davis, hydraulic engineer, who is associated with Gen. W. Sooy Smith & Son.

THE June number of the *North American Review* opens with an article by Joseph Nimmo, Jr., Chief of the Treasury Bureau of Statistics, on "American Manufacturing Interests," in which is given a singularly full and instructive historical sketch of the rise and progress of manufactures in the United States, together with a very effective presentation of their present condition, and of the agency of tariff legislation in promoting diversified industries and encouraging the inventive genius of the people. Should this author's advocacy of protective legislation prove distastful, the reader finds the needed corrective in an article by the Hon. Wm. M. Springer on "Incidental Taxation," which is an argument of Free Trade. D. C. Gilman, President of Johns Hopkins University, writes of the "Present Aspects of College Training," as affected by the increase of wealth and luxury, the development of natural science, and the influence of a larger religious liberty. Edward Self presents some weighty considerations on the "Abuse of Citizenship," as exhibited in the machinations of the dynamitists against a friendly power, in disregard of the obligations of American neutrality. Prof. Isaac L. Rice criticises some of "Herbert Spencer's Facts and Inferences," in social and political science, and Christine Nilsson contributes "A Few Words about Public Singing." Finally, there is a symposium on "The Moral Influence of the Drama," the participants being, on the one side, the Rev. Dr. J. M. Buckley, well known as an opponent of the stage; and on the other, John Gilbert, the actor; A. M. Palmer, theatrical manager; and William Winter dramatic critic. 50 cents a number; $5 a year. Published at 30 Lafayette Place, New York.

Stuart's Granolithic Paving has been awarded the contracts for the approaches and sidewalks to the Custom House at New Orleans, and the Post Office and Custom House at Hartford, Conn. The work on the Philadelphia Post Office, corner 9th and Chestnut, begun last season is being rapidly pushed to completion by Dr. Filbert, the local agent.

THE IRON AND METAL MARKET.

PHILADELPHIA, May 24.

Iron prices in eastern Pennsylvania show a declining tendency, chiefly because of the situation in the west. Consumers are covering requirements for the next thirty days in finished iron. Pig iron is very weak. Brokers are endeavoring to sell large lots of forge iron to mill owners at prices ranging from $17 at furnace to $18. These low figures lead to no more business than is sufficient to meet current requirements. Eastern Pennsylvania stocks are large. And as a strike in the west will take place June 1, there will be a great abundance of crude iron in both eastern and western markets. Foundry irons are quoted for standard brands at $22 @$20. Inferior makes are offered every day $1 less. Total business during past week was less than one-half the average volume. Best refined iron 2.20@ 2.30c. Purchases are easily made at 2.15c. but the makes are not first-class. Heavy shipments of nails were made since Monday at $3 in car-load lots. Factories are endeavoring to maintain abundant assortments. Construction iron is very weak where large orders are presented. Old rails are offered at $23 for shipment. $27.50 for doubleheads. Cargo scrap is offered at $25. The general situation of the iron trade is satisfactory, but consumers will not cover summer requirements until the problem in the west is solved. Consumptive requirements are la ge.

PITTSBURGH.

The situation at present writing in western Pennsylvania is favorable to a suspension of iron making in Pittsburgh and throughout the West. Prices for finished iron are firmer than they have been for several months, and demand is sufficiently active to impart a fresh life to the trade, but it is due altogether to the expectation of a summer scarcity. Bar iron in large lots is being taken at 2c., and in small lots at 2.20c. Inquirers are coming along, and buyers are being assured that their wants can be provided for in the event of a suspension. This is having a quieting effect, and the manufacturers feel that there is no occasion for apprehending any real stringency during the summer. Several Western mills are idle, having accumulated stocks, and they will not continue after June 1, except at the drop. There are rumors on the street of a probable compromise, but nothing definite can be ascertained. The workmen are not so confident of gaining their point, and might yield rather than remain idle sixty or ninety days. Nails are in active demand at $3@$3.25. Pig iron is unusually weak, and one sale of the bankrupt iron showed that prices have fallen to unprecedentedly low figures. Makers are piling up stocks. In construction iron there is fair activity, though no large orders have been heard of. In steel rails orders were placed at $39 for heavy sections. Old material sold at $23. Scrap is without activity, and is fluctuating.

CHICAGO.

A disturbing element has arisen and it is to be attributed to the strong probability of a strike, which now seems to be unavoidable. Prices have touched bottom, and no further decline is looked for. Tank and Angles are 3.10c.; Beams 3c.; Channels 4c. There is a very active demand for nails, and the market is much stronger. Dealers and consumers fear the strike, and are trying to provide their summer supply. Orders for Tubes and Pipes during the week have been few. Prices are not firm at present quotations, 70 and 10 per cent. off on pipes, and 60 per cent. off on Tubes. There has been a fair demand for pig tin, and prices remain unchanged. Scrap iron is not active, and there has been no change this week. Steel rails in eastern mills are quoted at $38@39. In western mills they are $41, the same as last week. There was very little demand for Merchant steel, and no permanent improvement has been noticed. It is thought that there was a good deal of shading done to secure good orders. Buyers of pig iron are only providing for immediate requirements. Consumption has been restricted, and purchasers only take a car-load at a time. Trade is extremely weak. The ore market is unsettled, and furnacemen are asking lower prices. A few sales were made, but it is said at reduced rates. Quotations remain essentially the same as last reported. A fair trade is expected in foreign irons. Prices are unchanged, with few exceptions, and small sales are being made. Prices in the hardware trade show a downward tendency, but there is considerable improvement visible.